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A CRITICAL REVIEW OF THE WORLD LITERATURE IN APPLIED MECHANICS AND RELATED ENGINEERING SCIENCE

Published Monthly by THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS at Easton, Pa., and edited by Southwest Research Institute with the co-operation of Linda Hall Library

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APPLIED MECHANICS REVIEWS

VOL. 10, NO. 9 MARTIN GOLAND *Editor* SEPTEMBER 1957

ON THE PHILOSOPHY OF 'RELAXATION'

SIR RICHARD V. SOUTHWELL

The Editor, when he invited me to write this feature article, pleased me greatly by his prompt approval of its theme; because again and again, while at work on the volume which ends my account of 20 years' development of relaxation methods, I had been tempted to expatiate on the 'philosophy' that underlies them, but had refrained since this would extend a treatise already longer by three chapters than I intended when I started it in January 1941.* Looking back on what a small team of enthusiasts has done since my first two papers on 'the method of systematic relaxation of constraints' appeared in 1935, I count it fortunate that from the outset our interest centered on 'philosophical' aspects: not only (as is usual) on convergence, but on all implications of its most essential feature—that throughout attention is focused not on the 'wanted' quantities or functions but on the 'residuals' (viz. on those parts of the specified 'load terms' which remain 'not yet accounted for'). Fresh implications continue to be noticed, but even of my first paper the main contention was that in 'real' problems (those which are met in physical and engineering studies) all data have their 'margins of uncertainty'—inescapably, since no measurement or designer's estimate is precise. My first papers dealt with frameworks (and on that account we have come to speak of 'load terms' in our equations): it rested squarely on the contention that in real design the scantlings of members, despite manufacturing tolerances, are known far more precisely than the loads, which—especially those imposed by natural winds—as a rule can only be conjectured. Each load is specified only within some margin of uncertainty; and when every load has been 'accounted for' within its margin, to do more would be not only a waste of time but *meaningless*, since no solution has more claim to be called exact than what has been found already.

Once started, the contention seems irrefutable; and it holds, *mutatis mutandis*, for every physical problem—or at least, for every one that we have treated. Mathematically, 'residuals' are simply errors: *viewed physically, they are changes in the data which, if they could be made in fact (and were), would leave us with a perfectly exact solution.* They need not in fact be forces, though their significance is clearest when they are. (For example, when the problem relates to mechanical vibrations, we can deduce from them changes of density which, if effected, would make the solution already found exact. When the vibrations are electrical—as in Examples LIV and LV of my vol. 2—the alterations would be of permeabilities or of dielectric constants.) Sometimes we may not be able even to conceive of ways in which the requisite changes could be made: this does not matter provided that, *intuitively*, we can tell whether the consequences would be appreciable. Our claim is that in fact we have this power in respect of any problem which we understand sufficiently to be able to formulate it in equations; that we *can* judge when residuals are small enough to be accepted.

2. But we must realize what adoption of this standpoint means: to accept 'unliquidated residuals' is to do what in logic is indefensible—*it is to leave unsolved a problem exactly similar in kind to the problem which confronted us initially.* What rejoinder, then, can we make to a mathematician who points this out with the shudder of a man obliged to witness commission of an unforgivable sin? None save this, I think, that speaking professionally he is entirely right, but that so—also speaking professionally—are we: because the problems which confront engineers and physicists leave them no option but to put trust in intuition.

One example must suffice:-Suppose (what is never the fact) that the weights and scantlings of all members of some bridge were known exactly, and that (again, by a miracle) its design were such as to make their stresses precisely calculable: then, as regards 'dead-load stresses' and/or those entailed by a specified 'live loading', the designer's problem would be defined in the strict mathematical sense. Fine!—but what if, after it is erected, a bird or a flight of birds should elect to perch on his bridge some day? The possibility cannot be dismissed, and the designer can know neither the number of the birds, nor their weights, nor where they will settle. Ought he, then, to hesitate to let his bridge be built? No engineer will think so; he knows that the birds will do no harm. But he knows by intuition, not by reasoning.

3. As I believe, every engineer needs to realize that his outlook and that of the mathematician are, in the last resort, irreconcileable; that this disregard of perching birds and of 'acceptable' residuals is quite different from the sort of approximation that is implied by the examination rubric "*Use of slide rules is permitted*". The problems that confront him in real life are not like those that used to confront him in examinations; which, by maintaining the fiction that loads are

*Vol. 1 was published in 1946, and its preface explained why vol. 2 would be delayed. An introductory treatise—*Relaxation Methods in Engineering Science*—had appeared in 1940.

known precisely, implied that exact solutions are practicable. They gave the loads as 5 tons here and 10 tons there, not as 5 ± 0.1 and 10 ± 0.2 tons (and in real life margins are far wider); in part, I think, because their traditional form (stemming from the early days of engineering science) is modelled on that of mathematical questions, where the data (being purely conceptual *are* exact.

To maintain that two outlooks are irreconcilable is not to dispute the validity of either—its validity *in its proper sphere.* Mathematics is concerned with ideal concepts, true in any imaginable world: physicists and engineers seek to understand and (in some degree) to control a world which imagination cannot alter, *a world in which no data are precise.* Every engineer has need of mathematics, since design entails computation; but (in his professional capacity) not as an end in itself, but as a tool—and as only one tool of many that he must use, another being intuition. If the difference (as I believe) is real and *for both parties right and proper,* engineers should see it not merely as a fine distinction. It has consequences which ought to color all our thinking.

4. In particular (and to urge this is the main purpose of my article) it should modify our outlook on finite differences—result in a new attitude to the question:-What error is entailed by substitution of a net of finite mesh-size for a *continuum,* a net supporting loads at its nodal points for the mathematician's 'membrane'? The more I reflect on problems that I call real, the more surprising I find the readiness of many authors to base *all* numerical work on an assumption which has no parallel in experimental physics *and which they themselves would not make in analysis:* the assumption that every function which they seek to evaluate can be expressed in 'Taylor series' form, that its derivatives of all orders are continuous. They make it every time they maintain that improvement *must* result from working with differences of higher order, *because every one of the formulae they utilize postulates that the wanted function is a polynomial.* It is, of course, quite unexceptionable as a basis for mathematical studies aimed at tracing its consequences, and on it mathematicians have erected a superstructure of great elegance and extent. But as a basis for techniques to be employed in engineering I judge it to be unsafe; for in the fields where numerical methods are needed most, discontinuity of one or more derivatives is the rule rather than the exception.

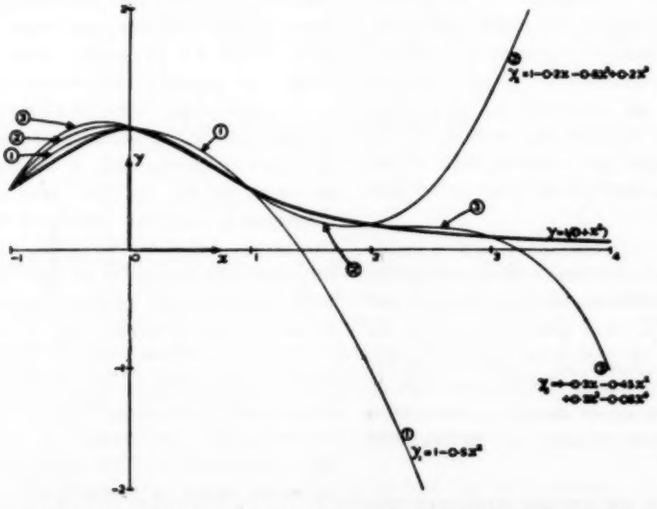
Some few years ago (1, pp. 71-2) I showed by an example that increasing the order of a polynomial (i.e., the number of the point-values which determine its coefficients) may lead not to improved approximation but to the reverse—and this in the range that matters most. My example was the function $y \equiv (1 + x^2)^{-1}$, and I considered three 'polynomial approximations' (cf. Fig. 1),

the first (quadratic) giving y correctly for $x = 0$ and ± 1,
" second (cubic) " y " for $x = 0, \pm 1$ and 2,
" third (quartic) " y " for $x = 0, \pm 1, 2$, and 3.

Only the first gives y_0' $(=0)$ and y_0''' $(=0)$ correctly, and *all three underestimate* y_0'' $(=-2)$ *by 50 per cent or more.* No choice of function could have exemplified more tellingly my contention that the engineer's outlook differs essentially, *and rightly,* from that of the mathematician: for two mathematicians hastened to point out that I might have foreseen all this from the circumstance that $(1 + x^2)^{-1}$ has singularities at $x = \pm i$; whereas my concern was with curves representing experimental data *and as such having no known analytical form*—and for real x (cf. Fig. 1) the function $(1 + x^2)^{-1}$ yields a curve of the kind we obtain from stress-measurements made on 'waisted' specimens. *Numerical methods are not merely an alternative to analysis: our real need of them arises when analysis is impracticable.*

5. What is the case for the polynomial assumption? Not all authors state it as plainly as do Whittaker and Robinson in their presentation of the Gregory-Newton interpolation formula. They are discussing the problem of drawing a curve to pass through a number of plotted points A,B,C,D, . . ., and here is what they say (in a footnote to §8 of their *Calculus of Observations*): We do not know anything about the portions of the graph intermediate between these points, but we assume that the graph is a smooth curve; for our present purpose we can take this to mean that the function has finite differential coefficients of all orders at every point." They continue: "As our aim is a practical one, we naturally choose the simplest solution of our problem. Remembering that *the simplest functions are polynomials,* we inquire . . ., etc." *The italics are mine:* used because, as it seems to me, this sort of simplicity is *not* a self-evident criterion of a function's suitability.

For how would this problem of 'plotting' be approached by a physicist or engineer *whose points A,B,C,D, . . . are based on measurements?* Being concerned to discover laws he believes to be inexorable, he dares not make assumptions regarding their forms outside of his experimental range, and even within it he knows that his deductions must be tentative. His 'hunch' is that the laws have continuity in the sense that additional observations would have added points falling on a smooth curve through A,B,C,D, . . . , and he 'sketches' his tentative curve conformably; but so far is he from postulating continuity of *all* derivatives that he seldom gives it more than continuity of curvature—and is sometimes content with mere



Curve of $y = 1/(1 + x^2)$ and of three 'polynomial approximations'.
Fig. 1 (Fig. 4-2, Chap. 4, of Ref. 1—reproduced by permission).

continuity of slope. *Least of all will be postulate its curvature where the curve goes outside the range of his observations:* if he does extend his sketch beyond that range, he will make its curvature zero or very small there–i.e., keep its slope very nearly constant. One may say that he seeks to estimate the curve that would be assumed by a flexible lath made to pass through A,B,C,D,... by smooth pins penetrating it at those points; and that this curve has a continuous second derivative (curvature) since the pins exert no moments, but a discontinuous third derivative (shear) since forces are required to hold the lath, and outside of the outermost pins no curvature–i.e., constant slope.

Nor can this choice be explained as due to mathematical insensitivity: it is based on sound physical reasoning. For while a finite number of observations can provide no case for assuming discontinuities of *value* (such as are found in metals exhibiting a 'drop of stress at yield'), equally it can give no support for the assumption that every derivative of the wanted curve has continuity—this is known to contradict the facts in many well-understood problems. In physics, mathematical presumptions are out of place—*"Entia non sunt multiplicanda praeter necessitatem"*—and outside the range of a set of observations nothing can be deduced from them. We violate William of Occam's canon when we make the 'polynomial assumption'; because all polynomials, of whatever order, *tend to infinity with the independent variable.*

6. What, then, ought we to do about finite differences? As I believe, simply this:–Recognize the inescapable uncertainty of physical data and, to meet it, introduce the concept of 'residuals'; then, on this base a new Calculus of Observations. Hardly a task to be attempted in a feature article! but one pointer may be noticed—Clapeyron's well-known Theorem of Three Moments. No one, so far as I know, has remarked its relevance to the calculus of finite differences; yet this follows from the view of experimental plotting which has been stated, since the theorem yields a relation that must be satisfied if the curve representing a wanted function $y = f(x)$ is to be continuous as regards all of y, y' and y''. (The relation does *not* ensure continuity of y'''. Why should it, if y results from a loading which includes concentrated forces?)

7. As presented (e.g.) in (3), §§70–1 and Figs. 25 and 26, the theorem concerns two consecutive spans, having any lengths, of a continuous girder, so relates to the flexural equation

$$-EI\,d^2y/dx^2 = M. \qquad [1]$$

Here the two spans (intervals) will be taken as equal, and no particular application is contemplated; so a new presentation seems desirable, based on the equation

$$w'' + Z(x) = 0, \qquad [2]$$

in which the form of the function Z is supposed to be specified. Points 3 and 0 and 1 in Fig. 2 typify three consecutive points of subdivision spaced with a uniform interval a, and a relation is wanted between the ordinates w_3, w_0 and w_1 of a curve in which all three of w, w' and w'' are single-valued. It is presumed that Z has some finite 'margin of uncertainty' and that the derived curve of w will be 'sketched' through the points C, A and B, so will also be in some degree indefinite.

Drawing chords *hk*, *kl* of the $Z(x)$ curve, as shown, and using $\zeta(x)$ to denote the excess of $Z(x)$ above the ordinates of the resulting linear figure (so that $\zeta = 0$ at 3 and 0 and 1), we have in the range $0 \longrightarrow 1$ (when x is measured from 0 in Fig. 2)

$$Z(x) = (1 - x/a)Z_0 + (x/a)Z_1 + \zeta(x),$$

therefore on one integration of [2]

$$w' = w'_0 - \int_0^x Z(x')\,dx'$$

$$= w'_0 - x\{Z_0 - (Z_0 - Z_1)\,x/2a\} - \int_0^x \zeta(x')\,dx', \qquad [3]$$

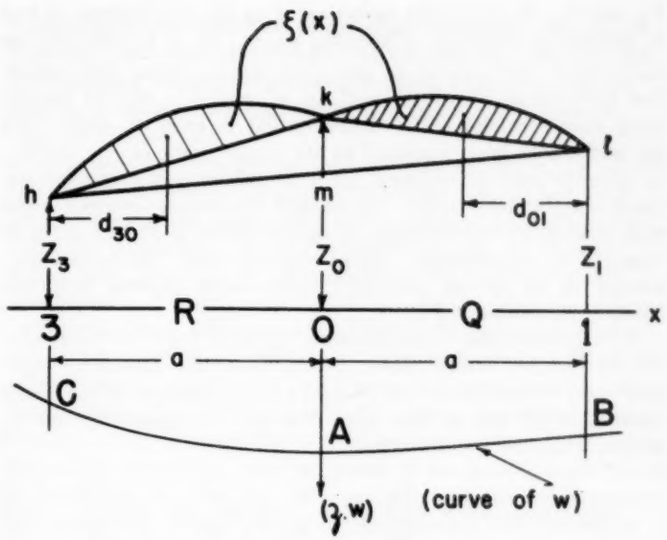


Fig. 2 Equation (2) solved on the basis of Clapeyron's theorem.

and hence on a second integration

$$w = w_0 + x \cdot w'_0 - \tfrac{1}{2}x^2\{Z_0 - (Z_0 - Z_1)\,x/3a\} - \\ - x \cdot \int_0^x \zeta(x')\,dx' + \int_0^x x \cdot \zeta(x')\,dx'. \qquad [4]$$

Giving to x the value a, we have from [4]

$$w_1 = w_0 + aw'_0 - a^2(2Z_0 + Z_1)/6 - A_{01} \cdot d_{01}, \qquad [5]$$

A_{01} denoting the shaded area $= \int_0^a \zeta(x)dx$, and d_{01} (cf. Fig. 2) the distance of its centroid from the vertical through 1; and by similar treatment of the range $0 \longrightarrow 3$ we obtain

$$w_3 = w_0 - aw'_0 - a^2(2Z_0 + Z_3)/6 - A_{30} \cdot d_{30}, \qquad [6]$$

A_{30} having similar significance to A_{01}, and d_{30} (cf. Fig. 2) being measured from the vertical through 3. Then, *postulating that w'_0 is single-valued*, we have on addition of [5] and [6]

$$w_1 + w_3 - 2w_0 = -Z_0a^2 - a^2(Z_1 + Z_3 - 2Z_0)/6 - \\ - A_{01} \cdot d_{01} - A_{30} \cdot d_{30} \qquad [7]$$

—recognizable as an alternative statement of Clapeyron's theorem.

8. In [7], the term $-a^2(Z_1 + Z_3 - 2Z_0)/6 = a^2Z_0/3$, when Z_0 stands for the intensity of loading represented by km in Fig. 2. In general Z_0 decreases rapidly with a, as also do A_{01} and A_{30}; and in fact, when [7] is replaced by the familiar approximation

$$w_1 + w_3 - 2w_0 \doteqdot -Z_0a^2, \qquad [8]$$

it is apparent that the neglected terms will usually be small of the order of Z_0a^4 *at least.* But [7], *which entailed no assumption other than that w'_0 is single-valued*, points the way to much closer approximation:–Replacing the two bold-line curves by parabolas passing through their middle points, we easily derive

$\frac{2}{3}a\{Z_{x=\frac{1}{2}a} - \frac{1}{2}(Z_0 + Z_1)\}$ as an approximation to A_{01},

$\frac{2}{3}a\{Z_{x=\frac{1}{2}a} - \frac{1}{2}(Z_3 + Z_0)\}$,, ,, ,, ,, A_{30}, and

$\frac{1}{2}a$,, ,, ,, both to d_{01}

and to d_{30}; therefore as a closer approximation to [7] than [8]

$$w_1 + w_3 - 2w_0 \doteqdot -\frac{a^2}{3}(Z_0 + Z_Q + Z_R), \qquad [9]$$

Z_Q and Z_R denoting the values of Z at the two points, Q and R, distant $\frac{1}{2}a$ from 0. Choosing w_1, w_3, w_0 to satisfy [9], we have three ordinates of an imagined 'spline curve' (§5) which has continuous (single-valued) w, w' and w'', *not* (of necessity) single-valued w'''. Equation [9] is easy to apply, and the additional labor entailed by its involvement of Z_Q and Z_R is recompensed by reduced labor in subsequent computations (with smaller intervals). To attempt yet closer approximation will seldom be worth while in cases where $Z(x)$ has a finite 'margin of uncertainty'; it has already been 'accounted for', except in so far as its (bold line) curve departs from the (dotted) parabolas in Fig. 2.

9. In general the 'load function' $Z(x)$ will *not* be expressible in 'Taylor series' form. When it is, the foregoing argument can be reinforced by an exact determination of the terms omitted in [8] and in [9]. From the series expressions for w_1 and w_3 it can be deduced that

$$w_1 + w_3 - 2w_0 = 2\left[\frac{a^2}{2!}w_0'' + \frac{a^4}{4!}w_0^{iv} + \frac{a^6}{6!}w_0^{vi} + \cdots\right] \quad [10]$$

$$= -2\left[\frac{a^2}{2!}Z_0 + \frac{a^4}{4!}Z_0'' + \frac{a^6}{6!}Z_0^{iv} + \cdots\right], \quad [11]$$

in virtue of (2); and from the series expressions for Z_Q and Z_R we have an equation similar to [10] – viz.

$$Z_Q + Z_R - 2Z_0 = 2\left[\frac{1}{2!}\cdot\frac{a}{2}^2\cdot Z_0'' + \frac{1}{4!}\cdot\frac{a}{2}^4\cdot Z_0^{iv} + \cdots\right]. \quad [12]$$

Using [12] we can replace [9] by

$$w_1 + w_3 - 2w_0 \doteq -\frac{a^2}{3}\left[3Z_0 + \frac{a^2}{4}Z_0'' + \frac{a^4}{8.4!}Z_0^{iv} + \cdots\right]$$

$$= -2\left[\frac{a^2}{2!}Z_0 + \frac{a^4}{4!}Z_0'' + \frac{5}{8}\frac{a^6}{6!}Z_0^{iv} + \cdots\right], \quad [13]$$

and comparison of [13] with [11]—which is exact—shows that [9] is in error only as regards terms small of the sixth and higher order in a, the terms omitted from its right hand side being $\left(-\frac{3}{4}\cdot\frac{a^6}{6!}Z_0^{iv}\cdots \text{ etc.}\right)$; whereas the terms similarly omitted in [8] are

$$-2\left(\frac{a^4}{4!}Z_0'' + \frac{a^6}{6!}Z_0^{iv} + \cdots \text{etc.}\right). \quad [14]$$

(Use of [11] was made in §209 of my 1940 volume, also in §191 of my 'Elasticity' (Ref. 3), where an "initial modification of the specified loading" was shown to yield (theoretically) exact results. The "modification" is replacement of $Z(x)$ by

$$Z(x) + \frac{2a^2}{4!}Z''(x) + \frac{2a^4}{6!}Z^{iv}(x) + \cdots \text{etc.} \quad [15]$$

10. Much remains to be done, of course, with other operators. This note attempts only to indicate an alternative ('engineer's') approach to finite differences, and the relevance of the well-known Theorem of Three Moments. (It would seem an appropriate year in which to remark that relevance, being the centenary of Clapeyron's first enunciation (2) of his theorem.)

REFERENCES

1 *Numerical methods of analysis in engineering* (ed. L. E. Grinter). New York, Macmillan Co., 1949.

2 Clapeyron, B. P. E., *C. R. Acad. Sci. Paris* **45**, 1076–80, 1857.

3 Southwell, R. V., *Introduction to the Theory of Elasticity* (2 ed., Oxford Univ. Press, 1941).

"Letters to the Editor" and "Books Received for Review" appear after the reviews

Theoretical and Experimental Methods

(See also Revs. 2768, 2771, 2772, 2779, 2782, 2785, 2792)

Book—2749. Rothe, R., and Schmeidler, W., Higher Mathematics, Part VII. Spacial and plane potential functions. Conformal mapping, integral equations, variational calculus [Hohere Mathematik, Teil VII. Raumliche und ebene Potentialfunktionen, Konforme Abbildung. Integralgleichungen, Variationsrechnung], Stuttgart, B. G. Teubner Verlagsgesellschaft, 1956, 218 pp. DM. 22.40.

After author's death, Rothe's well-known "Higher mathematics" (3 vols. + 2vols. problems and formulas) has been continued to cover fields of mathematics which in the last two decades have won more and more importance for engineers. Volume VI deals with differential equations; the present volume with potentials, conformal mapping, integral equations, and calculus of variations. Written by an excellent mathematician, the text never loses contact with its chief aim: to provide physicists and engineers with the tools necessary for their business.

Many German books, unfortunately, ignore problems; this one one gives 61 with answers, a valuable part of a book whose concentrated writing requires active collaboration of the reader.

K. Marguerre, Germany

2750. Kronberg, V. A., First variation of the solution for boundary-value problems in the theory of the potential with a variable boundary surface (in Russian), *Prikl. Mat. Mekh.* **19**, 4, 463–470, July/Aug. 1955.

Author defines the variation surface in terms of a first variation in the radius vector for the original surface, the radius vector for the new surface being the radius vector for the original surface plus the product of ϵ, a unit normal vector, and an arbitrary function η with the required continuity and differentiability conditions. By expressing the solution of various problems in potential theory for the new surface in terms of the solution for the original surface plus its first variation, author evaluates this first variation in terms of the function ϵ and functions defined in terms of the original surface.

Paper was translated by V. A. Valey, USA, prior to review.

B. E. Gatewood, USA

2751. Winn, E. A., A matrix method for the numerical solution of linear differential equations with variable coefficients, *J. roy. aero. Soc.* **61**, 554, 133–134 (Tech. Notes), Feb. 1957.

Presented method is applicable to linear ordinary differential equations of any order and requires mainly the reciprocation of a matrix of order equal to the number of points for which a solution is to be obtained. The differential equation is considered at these points. This gives a linear system of equations written in matrix form from which, after substituting well-known integrating formulas, author gets the solution. As an example there is given a second-order equation with boundary conditions.

R. Albrecht, Germany

2752. Schwarz, H.-R., A method related to the stability question within matrix eigenvalue problems (in German), *ZAMP* **7**, 6, 473–500, Nov. 1956.

Given a real or complex matrix A, the eigenvalue problem consists of finding the λ value satisfying the equation $(A - \lambda E)x = 0$. On the other hand, stability question for eigenvalue problem is finding the λ value with negative real part.

Classical methods are based on Sturm polynomials which are deduced from characteristic polynomials of matrix; moreover, its coefficients do not give any information about the original elements of the matrix.

Author develops a new method which avoids this difficulty. The given matrix A is transformed into a reduced form by applying a finite series of elementary transformations. The elements of the reduced form allow immediate solution of the stability question without evaluating the characteristic polynomial. Furthermore, the characteristic polynomial is formed in a direct manner from the elements of reduced matrix.

The procedure is well adapted for use in computing machines.

J. N. Aguirre, Argentina

2753. Householder, A. S., On the convergence of matrix iterations, *J. Assn. Comp. Machy.* **3**, 4, 314–324, Oct. 1956.

For n-dimensional vectors and n by n matrices, author describes a class of norms with properties useful for study of problems related to solution of systems of linear equations. For one of his applications, consider system (*) $(I - B)x = b$, where matrix I has ones on diagonal, zeros elsewhere, and B has zeros on diagonal. Let $|B|$ be matrix whose elements are absolute values of corresponding elements of B. Let β be maximum of absolute values of characteristic roots of $|B|$. Author uses his norms to prove that Gauss-Seidel and total step iterative methods for solving system (*) converge if $\beta < 1$. To verify this condition he describes two methods to generate sequences of norms of B that decrease monotonely to β.

J. H. Giese, USA

2754. Schröder, J., Difference method in nonlinear boundary-value problems (in German), *ZAMM* **36**, 9/10, 319–331, Sept./Oct. 1956.

Author considers

$$\Phi + f(x, \Phi) = 0,\ 0 \le x \le l,\ a\,\Phi(0) - bl\,\Phi'(0) = A_0,$$
$$c\,\Phi(l) + dl\,\Phi'(l) = A_l$$

replacing this system by a particular system of difference equations. Iteration procedes from an assumed approximation by successive solution of linear equations. Convergence proof and error estimates are given.

A. S. Householder, USA

2755. Lotkin, M., Note on the sensitivity of least squares solutions, *J. Math. Phys.* **35**, 3, 309–311, Oct. 1956.

When solving problems which concern fitting of test data by least square methods, it is often of interest to know the effect of data error on the solution. Present paper gives a matrix analysis of the problem. A numerical example is provided.

Y. L. Luke, USA

2756. Walker, J. W., Some data processing and engineering calculations with slow to medium speed computers, *J. Petr. Technol.* **8**, 12, 17–23, Dec. 1956.

Paper describes methods of solving several reservoir engineering and data-processing problems using slow to medium-speed computing machines. The problems handled are:

(1) Solution of the Hurst-van Everdingen material balance equation for which at first only water influx terms and y curves for PVT samples were calculated with the IBM 602A and 604 computers, while later the complete solution of the equation was programmed on the IBM 607 computer. The application of this equation requires computing cumulative water influx volumes at successive dates and matching these figures with the difference between the corresponding cumulative reservoir volumes withdrawn, and the corresponding cumulative expansions of the initial volume of reservoir oil and gas.

(2) Vapor-liquid equilibrium flash calculations which are solved rapidly with the IBM 602A or 604. Auxiliary calculations were made to convert the results into usable engineering quantities.

(3) Statistical analyses, performed on core data for several fields, providing a better understanding of the reservoir characteristics.

(4) Preparation of the annual (statistical) reserve report. This report starts with the previous year's figures for the gross and net reserves, cumulative and ultimate production separated into oil, condensate and total liquid figures by leases. Revisions to reserves, classified according to 10 categories such as discoveries, new zones, extensions, etc., are added to the opening reserves and ultimate production figures, while the yearly production figures are subtracted from the revised figures and added to the cumulative figure. Statistical data concerning leasehold titles and ownership fractions, well counts, etc., are recorded. All figures are summarized according to zones, fields, leases, divisions and areas.

(5) Miscellaneous uses of analytical procedures for production, accounting figures, such as oil pipeline runs, etc., provide better control of production operations.

From author's summary

2757. Reich, J. A., and Gurney, W. B., The information center with automatic logger and scanner at Neches power station of Gulf States Utilities Company, ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56-A-219, 13 pp. + illus.

2758. Moore, E. F., and Shannon, C. E., Reliable circuits using less reliable relays. Parts I, II, *J. Franklin Inst.* **262**, 3, 191–208, Sept. 1956; **262**, 4, 281–298, Oct. 1956.

Relays often used in computers and safety devices are not always reliable. Investigation is made of relays whose reliability can be described in simple terms by means of probabilities. It is shown that, by using a sufficiently large number of relays in proper manner, circuits can be built which are arbitrarily reliable. Theoretical treatments of design of arbitrarily reliable circuits are given. The circuits thus derived require fewer elements than von Neumann's for prescribed reliability.

Y. Takahashi, Japan

Book—2759. Lehmer, D. N., List of prime numbers from 1 to 10,006,721, New York, Hafner Publishing Co., 133 pp., 1956.

Book—2760. Lehmer, D. N., Factor table for the first ten millions, New York, Hafner Publishing Co., 476 pp., 1956.

These volumes are valuable, and the publishers are to be commended for making available to the scientific public a hitherto rare piece of work, first published about four decades ago. The introduction in each book gives a history of the subject and instructions for use of the tables. Comparisons are made of similar tables and errors are noted. Reviewer has found the tables useful in a number of instances in numerical analysis and other topics. Here it is often necessary to deal with coefficients in exact form, and the tables remove the tedium for finding factors by number-theory techniques. In this regard, the common handbooks list factors for numbers up to about 2000, which is virtually inadequate.

Y. L. Luke, USA

2761. von Hoerner, S., Generation of random numbers on computers (in German), *ZAMP* **8**, 1, 26–52, 1957.

Some of the available methods for the arithmetical generation of random numbers on electronic computers are discussed. The basic notions (mixing of digits, fixed and stable cycles and degeneration) and different ways of testing are introduced and investigated.

A new method is developed avoiding stable cycles and degeneration. Theoretical estimates and several tests gave full agreement.

As an example of the physical generation of random numbers, the counting of Gammaquanta is treated theoretically. The estimates have been confirmed using a simple physical generator, built in the computer G2 of the Max-Planck-Institut für Physik, Göttingen. From author's summary

2762. Weihe, V. I., Airborne computers will reduce cockpit workload, *Aero. Engng. Rev.* **16,** 5, 75–78, May 1957.

2763. Hess, S. L., A simple analog computer for determination of the Laplacian of a mapped quantity, *Bull. Amer. meteor. Soc.* **38,** 2, 67–73, Feb. 1957.

Author shows that in a map of isopotential lines spaced at equal increments of the Laplacian operator, the latter can be approximated with fair degree of accuracy for any point by an expression involving the sum of the inverse of the squares of the distances of the point in question to neighboring isopotential lines. The approximation is good as long as the ratio of distances in plus and minus direction on the same line does not exceed the value 2. For this case, author shows a simple method of determining the inverse squares and adding them by electromechanical means. Terminology and examples are entirely in the field of meteorology. Reviewer believes that the method could be extended to broader usefulness. V. Paschkis, USA

2764. Barnes, G., Hatchet or hacksaw-blade planimeter, *Amer. J. Phys.* **25,** 1, 25–29, Jan. 1957.

The hatchet or hacksaw blade planimeter consists only of a sharpened pointer, a rigid arm, and a knife edge. Its theory was first given by F. W. Hill in the *Philosophical Magazine* in 1894 and was later simplified by Satterly. Hill and Satterly showed that the numerical value of the area within a closed curve traversed in the proper manner by the pointer is equal to the product of the length of the planimeter arm and the net displacement suffered by the knife-edge as measured along an arc with the pointer at the center of curvature. The present paper gives a relatively simple derivation yielding essentially the same result but using an entirely different method of approach. It is also shown that the procedure for operating this planimeter can be simplified when determining areas within certain types of closed curves. The accuracy of the planimeter is discussed.

From author's summary

2765. Profos, P., and Keller, H., Graphical method for deriving transfer function of a transformation system from the frequency response (in German), *Regelungstech.* **5,** 1, 11–15, 1957.

Integral transfroms containing sine or cosine functions are shown to be graphically computable. Method is applied to obtaining the time history of a mechanism, given its frequency response.

C. Ablow, USA

Mechanics (Dynamics, Statics, Kinematics)

(See also Revs. 2780, 2836, 2838, 2840, 2841, 2842, 3112, 3116)

Book—2766. Mabie, H. H., and Ocvirk, F. W., Mechanisms and dynamics of machinery, New York, John Wiley & Sons, Inc., 1957, xii + 442 pp. $8.50.

This outstanding text features concise treatment of fundamentals and wider scope of advanced topics.

The first part, consisting of nine chapters, deals with concepts of mechanisms, forms of linkages, cams (with accent on analytical design), spur gears—including nonstandard systems, bevel-, helical-, and worm-gearing and gear trains, and featuring an introduction to digital and analog computing mechanisms and introduction to synthesis of mechanisms.

The second part—Dynamics of machinery—consists of four chapters and covers kinematics of machinery, particularly graphical analysis of velocities and accelerations (including Coriolis component acceleration), and kinematics of rolling elements, force analysis of machinery—showing effect and distribution of inertia stresses on machine elements, flywheels and gyroscopes, balancing of rotating and reciprocating machinery with introduction to vibrations; finally, full discussion of single-degree-of-freedom free and forced vibrations, and multi-degree of-freedom vibrations, the latter limited to application to rotating shafts.

There are many good problems at the end of each chapter, and a few chapters in the first part carry references for further study.

Reviewer finds the text adaptable to possible changes in sequence of topics presented to students, whenever course curricula may so demand, but feels the inclusion of a discussion on governors might add toward completeness of this book.

Z. W. Dybczak, Canada

Servomechanisms, Governors, Gyroscopics

(See also Revs. 2837, 3007, 3028, 3892)

Book—2767. Leonhard, A., Automatic control [Die selbsttätige Regelung], 2nd rev. ed., Berlin, Springer-Verlag, 1957, xii + 376 pp. DM 39.

This book is devoted to basic automatic control theory with emphasis on areas which have had extensive application. The reader is introduced to the subject through physical examples. The formulas for integral, proportional, and derivative control are developed and the frequency and indicial responses of systems under such control are given. Cases with lumped as well as distributed constants are treated. Extensive use is made of the Laplace transform. Frequency and transient response are linked through the Fourier integral. The role of characteristic roots is developed and practical means given for finding these roots. Multiple control problems are discussed. The book covers both on-off and continuous control.

Stability is introduced with the Hurwitz criterion. This is followed by an exposition of Leonhard's test, and the Nyquist-Bode frequency response approach. The concept of the transfer function for a linear system is extended to the describing function for nonlinear. Techniques for improving system stability are given. The book closes with methods for determining control parameters.

The numerous examples from all major fields of engineering make this book especially suited to needs of the designer directly concerned with the analysis and synthesis of control systems. The book contains a helpful and extensive table of basic types of control components with their indicial responses, transfer functions, differential equations, polar and reciprocal polar plots. This should assist the reader in the prediction of the performance of systems built up from such components. The writer believes that this book will prove to be a highly useful addition to the library of every control engineer.

R. Oldenburger, USA

2768. Babister, A. W., Stability and response of systems satisfying a second-order linear differential equation with time-dependent coefficients, *Aero. Quart.* **8,** 1, 78–86, Feb. 1957.

The differential equation considered is

$$(a_2 + b_2 r)\frac{d^2x}{dr^2} + (a_1 + b_1 r)\frac{dx}{dr} + (a_0 + b_0 r)x = 0,$$

where all the a's and b's are real constants.

The nature of the solution is investigated in the neighborhood of the singular point ($r = -a_2/b_2$), and the conditions are found for logarithmic terms to be absent.

The conditions for stability for large values of r are determined; the system is stable if

$$(a_0 + b_0 r),\ (a_1 + b_1 r),\ \text{and}\ (a_2 + b_2 r)$$

are all positive for large values of r.

The form of the response is considered and its oscillatory (or nonoscillatory) nature investigated. The Sonin-Pólya theorem is used to determine simple inequalities which must hold between the coefficients of the differential equation in any interval for the relative maxima of $|x|$ to form an increasing or decreasing sequence in that interval.

From author's summary by S. Z. Dushkes, USA

2769. Coales, J. F., An introduction to the study of nonlinear control systems, *J. sci. Instrum.* **34,** 2, 41–47, Feb. 1957.

Nonlinearity is explained and defined by deriving the law of superposition for linear systems and showing that it does not apply to nonlinear systems. Nonlinearities are inevitable in many control system components but in some cases a virtue can be made of necessity and the performance of a system improved by the use of nonlinear damping and, in some cases, of nonlinear gain. The position of nonlinearity in the system is important and any general analysis of a nonlinear system is exceedingly difficult unless the nonlinearity occurs in the forward loop immediately before the load.

Various authors have suggested methods of classification of nonlinearities but as yet no generally satisfactory system is available. Various methods of analysis have been worked out but only for low order systems with determinate inputs. These are quite successful but as yet no general method has been developed for the analysis of systems with random inputs.

From author's summary

2770. Krug, K., The dynamical behavior of a pneumatic controller (in German), *Regelungstech.* **4,** 3, 58–61, 1956.

Author describes a pneumatic regulator available from J. C. Eckhart A.G., Stuttgart. Analysis is that of a first-order linear system; regulator can be connected to provide either lag or lead control. Actual instrument may have valuable qualities; analysis in paper is highly schematic. P. Le Corbeiller, USA

2771. Bautin, N. N., Theory of a triggering reulator with a spring plate (in Russian), *Inzbener. Sbornik, Akad. Nauk SSSR* 22, 3-16, 1955.

In various mechanical time-measuring devices, one uses for purposes of regulation an elastic spring plate which interacts with the driving wheel. In this paper, author develops a theory of such a mechanism by first reducing the kinematic problem from circular geometry to two-dimensional linear geometry. Thus, the problem is treated as a system with two degrees of freedom. Subsequently, by ingenious introduction of boundary and initial conditions, author develops adequate differential equations describing the motion of the system. Solutions of these equations provide insight into dependence of the dynamic behavior of the system on various design parameters. Also, using the method of phase plane, it is found that there are several possible stable modes of operation of the system, depending on the choice of design parameters.

Reviewer feels that some simplification in rather cumbersome analytical computations could have resulted if technique of operational calculus had been used, particularly in the initial formulation of the theory of periodic intermittent movements.

B. Zarwyn, USA

2772. Oldenburger, R., Mathematical methods in the design of automatic controls (in German), *Regelungstech.* **4,** 9, 213–223, 1956.

Algebraic and analytical techniques have been used extensively in the science of automatic control to treat the stability, transient response, frequency response, and other characteristics of closed-loop physical systems. Algebraic equations, Laplace and Fourier transforms, functions of complex variables, convolution integrals, and statistics are among the topics that have played an important role in the development of controls of all types. Mathematical techniques have been employed with considerable success in the design of aircraft autopilots, engine governors, controls for chemical processes, and many other kinds of regulators and servomechanism equipment.

From author's summary

2773. Janssen, J. M. L., Applications and limitations of elementary methods in control engineering (in German), *Regelungstech.* **4,** 11, 273–276, 1956.

In the present paper, the boundaries between elementary and non-elementary methods are so drawn as to exclude differential equations and complex calculus from the elementary domain. On the other hand, vector diagrams and frequency-response diagrams are included. Graphical methods are mainly used.

Application of these methods gives rise, first, to a simple qualitative picture of what goes on in control circuits. This is a great help in the education of instrument engineers. In the second place, these methods enable one to make quantitative estimates of the control quality that can be attained in a given situation.

From author's summary

2774. Sager, N., Waite, J. H., Poppell, J. W., and Howland, W. S., Servomechanism for the regulation of blood pressure, *Rev. sci. Instrum.* **28,** 1, 34–40, Jan. 1957.

A blood pressure regulator for use in cases of shock, hypotensive anesthesia, and in medical research is described. The difference between measured and reference values of blood pressure is used to control the infusion rate of drugs acting on the cardiovascular system. Although the system is inherently nonlinear, it is stable when operated with restricted gain.

From authors' summary

2775. Boyd, D. M., Dynamic response of a top temperature control system, ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56-A-158A, 4 pp.

2776. Heintz, R. P., A new maximum power criterion for certain hydraulic control valves, ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56-A-158B, 7 pp.

2777. Pengelley, C. D., Frequency of a preloaded system, ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56-A-158E, 5 pp.

2778. Braun, H., Critical comparison of possible methods of controlled loading of lead accumulators (in German), *Regelungstech.* **4,** 9, 223–228, 1956.

The conditions for the various methods of charging large lead accumulators are discussed, and the processes and controllers in question are studied and compared with regard to their applicability. In the course of this, the suitable combinations are found.

From author's summary

Vibrations, Balancing

(See also Revs. 2800, 2932, 3151)

2779. Clerc, D., On the iterative calculation of higher natural modes (in French), *Rech. aéro.* no. 54, 39–48, Nov.–Dec. 1956.

The usual iteration process for determining characteristic values and vectors of matrices always converges toward the largest characteristic value with corresponding vector (= lowest natural mode). In order to obtain convergence toward the other modes, the matrix must be transformed. This transformation can be performed in different ways. In the method given by Frazer,

Duncan and Collar ["Elementary matrices," University Press, Cambridge, 1938], the transformed matrix contains one zero column. Author presents method in which transformed matrix has one zero row. This method, which had already been given by reviewer [AMR **5**, Rev. 2467], has the advantage that only characteristic columns but no characteristic rows need to be determined. Author brings method in form which avoids the explicit calculation of the transformed matrices.

Later experience of reviewer makes him prefer method of deflation [Aitken, *Proc. roy. Soc., Edinburgh* **47**, 269–304, 1937]. This requires the determination of both characteristic columns and rows, but only in half the number of digits which is wanted for the characteristic values. Hence the total number of iteration steps is the same as that with author's method. If no separate iteration steps are required for the determination of the characteristic rows, it is even less. Moreover, deflation has the advantage of leaving characteristic vectors invariant, which is not the case with author's method. A. I. van de Vooren, Holland

2780. Erugin, N. P., Methods of solving stability problems on a large scale (in Russian), *Trudi 2-go Vses. sovesbcb. po teorii avtomat. regulirovaniya, Moscow-Leningrad, Izd. vo. Akad. Nauk SSSR* **1**, 133–141, 1955; *Ref. Zh. Mekh.* 1956, Rev. no. 2627.

A comprehensive survey. The equations of disturbed motions are examined

$$\frac{dx_x}{dt} = a_{kj}\, x_1 + \cdots n\, a_{kn}\, x_n + f_k\,(x_1 \cdots x_n) \qquad [1]$$

where a_{kj} are constants, f_k certain continuous functions. In the investigation of the stability of undisturbed motion, $x_1 = \cdots = x_n = 0$, at sufficiently large initial deviations, a series of characteristic problems occur. It is required to find criteria which insure stability according to Lyapunov, and the property $x(t) \to 0$ at $t \to \infty$ for a sufficiently large range of initial data (or even for all initial data) to determine the boundary of the area of limitation of the solutions, or the boundary of the region of attraction of the point $x = 0$. The character is given of the basic method of solving these problems, the author concluding that Lyapunov's methods are a valuable method of investigation. For complete solution of the problems, however, certain new methods are also required. The directions are indicated in which the development of the second Lyapunov method proceeded, and also other methods of the qualitative theory of differential equations applicable to the new nonlinear stability problems. Problems are formulated which are connected with the further development of these methods. Paper gives results obtained by a number of authors for certain types of the system of equations [1] by the second Lyapunov method, and also by qualitative methods developed by the author.

Courtesy Referativnyi Zhurnal N. N. Krasovskii, USSR
Translation, courtesy Ministry of Supply, England

2781. Myshkis, A. D., and Panovko, Ya. G., Effect of disturbing forces of variable frequency and amplitude on a linear system with one degree of freedom (in Russian) *Inzbener. Sbornik, Akad. Nauk SSSR* **22**, 33–41, 1955.

Using Duhamel's integral [see, e.g., Kármán-Biot, "Mathematical methods in engineering"], the response of the linear system with one degree of freedom to a force that is an arbitrary (under certain conditions) function of time can be obtained. The action of the force may be approximated either by application of a series of steps or a series of impulses.

Author studies the response of the system to a force of one ripple of the sine cruve. In the case when the actual disturbing force can be approximately substituted by a series of sine waves of various frequency and amplitude, the principle of superposition (summation) can be used to obtain the response of the system. Paper contains at the same time the limiting process marked out by the transition from summation to integration of responses to "wave impulses."

In one sense there exists some analogy between the results given in the present paper and the Fourier integral.

In some cases the substitution of the actual disturbing force by a series of sine waves is not admissible. The modification of the method for solving of such more difficult cases is given.

Reviewer would like to point out that the paper is well and simply written and contains a clear idea. By adding some illustrative examples, the value of present paper could be increased.
K. Julis, Czechoslovakia

2782. Belgaumkar, B. M., Limitations of voltage resonance in the electrical models of mechanical vibration systems, Proc. First Congress on Theoretical and Applied Mechanics, Nov. 1–2, 1955, 261–282, Kharagpur, Indian Inst. of Technology.

Author shows that, in the design of an electrical circuit analogous to a mechanical system by applying mobility method, care has to be taken to avoid interaction between the measuring circuit and the tuned circuit of the electrical frequency generator, out of which the circuit is fed. Interaction is more pronounced with voltage resonance than with current resonance, the latter mostly giving the right value of the natural frequency of the imitated mechanical system. Application of a damping resistor of suitable resistance in series with the circuit under investigation decreases the interaction and so prevents errors occurring.
R. G. Boiten, Holland

2783. Hu, H.-C., On the equilibrium and vibration of a transversely isotropic elastic body, *Scientia Sinica* **5**, 1, 1–18, Mar. 1956.

Paper carries on author's former investigations on the subject (published in Chinese, *Acta Physica Sinica* **9** and others). This time he gives the stress functions for the *special* solutions of the inhomogeneous equations, containing: body forces (1) perpendicular and (2) parallel to the planes of isotropy; (3) thermal load, eventually mass forces; (4) vibrations; and (5) wave propagation. The simplifications for bodies of revolution are specially dealt with. K. Marguerre, Germany

2784. Angelskii, D. V., Determination of the frequencies of free oscillations of elastic systems by the reduction of displacements (in Russian), *Proc. Moscow. Aviation Technological Institute* no. 25, 5-55, 1954; *Ref. Zh. Mekh.* 1956, Rev. no. 3113.

First the three-dimensional elastic system with three degrees of freedom is examined. In order to determine the direction of the main axes of oscillation and the so-called main "increments" of the system (values the converse of the rigidities of the system according to the main directions), author establishes the cubic equation, in external form similar to the equation known in the theory of elasticity for calculating the main stresses at the given point through the components of the tensor of stresses at the same point.

The analogy in question is further developed, the invariant relationships of the "displacement tensor" are used, expressions are given for the reduced displacements, equations are given for the determination of the actual frequencies for the case of two, three, and, in the case of symmetry, up to six degrees of freedom; these equations represent in essence a variant of the secular equation and of its solutions.

The concept of "the block", consisting of two or three masses with a minimum number of links, which gradually increases by means of the successive addition of new masses with the use of a minimum number of links, and problems of determining the frequency of the torsional oscillations of shafts are examined.

Courtesy Referativnyi Zhurnal N. I. Bezukhov, USSR
Translation, courtesy Ministry of supply, England

2785. Houbolt, J. C., and Brooks, G. W., Differential equations of motion for combined flapwise bending, chordwise bending, and torsion of twisted nonuniform rotor blades, *NACA TN* 3905, 47 pp., Feb. 1957.

Paper deals with structural and dynamic analysis of nonuniform rotor and propeller blades. Vibration and flutter problems, associated with critical design of present blades, require a more fundamental approach in developing general deformation theory. Differential equation of deformation of blade is derived for coupled-bending in two directions and torsion, of a twisted rotating beam, with non-coincident tension, elastic, and mass axes, under various applied loads. Internal elastic moments, equilibrium conditions, and body (centrifugal and vibratory) and applied (aerodynamic) forces are combined to obtain differential equation. Energy equations are used as a check. Deformation due to shear and other secondary effects are not considered. Simplifications appear under subcases of general theory.

Galerkin (modified) and Rayleigh-Ritz procedures are employed to obtain solutions. Two examples given.

Z. W. Dybczak, Canada

2786. Turbine blade vibration, *J. Amer. Soc. nav. Engrs.* **69,** 1, 102-116, Feb. 1957.

2787. Volterra, E., The equations of motion for curved and twisted elastic bars deduced by the use of the "method of internal constraints," *Ing.-Arch.* **24,** 6, 392-400, 1956.

Assuming that sections of a bar originally normal to its axis remain plane, and employing a straightforward variational approach, author derives equations of motion and boundary conditions for curved and twisted bars, taking into account influence shear and rotary inertia. No comparison is given between these equations and equations by other authors.

J. L. Bogdanoff, USA

2788. Hoppmann, W. H., II, Huffington, N. J., Jr., and Magness, L. S., A study of orthogonally stiffened plates, *J. appl. Mech.* **23,** 3, 343-350, Sept. 1956.

Stiffened plate is approximated by plate of homogeneous orthotropic material of uniform thickness. Rotary inertia and shear deformation have been neglected in theory. First author has previously proposed a testing method for determining elastic constants of equivalent orthotropic plate. In present paper, further experimentation is described and discussed. Three test plates are used for determining static constants; two rectangular plates, one grooved transversely and the other one longitudinally, for bending test, and one square plate grooved in one direction for twisting test. The square plate was also used in vibration tests for determining natural frequencies.

Agreement between measured and calculated results is good except for strains measured at plate surface in direction perpendicular to length of stiffeners, which strains are considerably larger than theoretical bending strains. It is considered that ends of strain gages were too close to stiffeners in fields of relatively high stress gradients.

G. Vedeler, Norway

2789. Hasselgruber, H., On the calculation of the natural frequencies of a slit circular ring of constant cross section oscillating freely in its plane (in German), *Forsch. Geb. Ing.-Wes.* **22,** 5, 158-166, Sept. 1956.

Author supposes that the circular axis of the ring is not disturbed and deduces a relation between the radial and the tangential displacements (u and v) as a consequence thereof. The equilibrium conditions for an element of the ring are written down and a differential equation of the sixth order is found for the amplitude of u, the independent variable being the angle at the center of the ring. To the boundary conditions at the free ends three integral conditions are added. The frequencies are found by means of the Rayleigh-Ritz method; symmetrical and antisymmetrical oscillations are distinguished. A special case is the slit full ring. A numerical example is given.

O. Bottema, Holland

2790. Feldinger, N., High-speed problems of cam drives with special consideration of the spring oscillations. Parts I and II (in German), *Forsch. Geb. Ing.-Wes.* **21,** 5, 159-163, 1955; **21,** 6, 181-188, 1955.

High-speed cam drives are of special importance for the control of fuel injection pumps. Author investigates a rotating cam which drives a follower into a periodic motion along a straight line. A spring presses the follower against the cam. The emphasis is on the limit velocity of the cam where the follower (at least once during a cycle) begins to lose its contact. The limit velocity is decreased by standing waves of longitudinal oscillations of the spring. Author's main objective is to reduce the waves. He discusses the effect of dampening the spring by friction as well as by dynamic means (variable spring constant). As the most effective way he proposes to change the cam so as to prevent the excitation of waves through the cam. He presents both experimental and theoretical results, and his discussion of cam changes includes numerical details about the calculation. Paper contains diagrams, oscillograms, and tables with valuable information.

H. F. Buckner, USA

2791. Savin, G. M., Basic dynamic equations of a mine lifting cable (load lifting) (in Russian), *Applied Mechanics* **1,** 1, 5-22, 1955; *Ref. Zh. Mekh. 1956,* Rev. no. *3122.*

In the selection of the relationships between the stresses and the longitudinal deformations of the cable, author bases himself on the oscillograms of free oscillations of the end load Q_0, obtained at various values of the initial amplitudes and length of rope.

The basic equations of the dynamics of a cable are derived during lifting of the load

$$\frac{-q}{g}\left(\frac{d^2\xi}{dt^2}-\frac{\partial^2 u}{\partial t^2}\right)=-\frac{\partial T}{\partial x}+q$$

$$\frac{Q}{g}\frac{d^2\xi}{dt^2}=Q-T(0,\ t)+R$$

where q is the weight of the linear length of the cable, ξ the variation in the length, u the absolute elongation of the cable of a length x, Q the weight of the load, T the stress in the cable, and R the force of resistance to movement of the load.

At the same time the following boundary and initial conditions are considered

$$u(0,\ t)=0,\frac{d^2\xi}{dt^2}=\frac{dv_c}{dt}+\frac{dl}{dt}\left(\frac{d^2u}{\partial t\partial x}\right)_{x=l}+\left(\frac{d^2u}{\partial t^2}\right)_{x=l}$$

$$u(x,\ 0)=m_1x+m_2x^2,\ \left(\frac{\partial u}{\partial t}\right)_{t=0}=m_3x$$

at

$$T=K\left(.1+i\frac{\delta}{2\pi}\right)\frac{\partial u}{\partial x}$$

where v_c is the velocity when removing the load, K the longitudinal rigidity, m_1, m_2, m_3 are constants, δ the damping decrement.

In the case of a small lifting depth

$$u(x,\ t)=x\epsilon\ (t)$$

the problem is simplified and reduced to integration of the equation

$$\frac{Ql}{g}\frac{d^2\epsilon}{dt^2}+\frac{Qv_c}{g}\frac{d\epsilon}{dt}+k\left(1+i\frac{\delta}{2\pi}\right)\epsilon(t)=\frac{Q}{g}\left(g-\frac{dv_c}{dt}\right)$$

in the boundary conditions

$$\epsilon(0)=m_1,\ \frac{d\epsilon(0)}{dt}=m_3$$

Based on the method of moments and starting from the basic equations, a new system of integral differential equations is plotted, by using which it is possible to obtain approximate solutions of the problem in question. At the same time the particular cases are indicated, for which the necessary solutions can be obtained fairly simply. G. S. Pisarenko, USSR

Courtesy Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

2792. Trense, R. W., The instability of cylindrical stop-beams in running water (in Dutch), *Ingenieur* **69**, 8, 10–13, Feb. 1957.

Paper attempts to obtain an easy mathematical interpretation of the relaxation oscillation of cylindrical bars or tubes. The method of Laplace transformation may be applied with success, as the simplification is achieved by linearization of the differential equation and as the initial conditions of the problem are given.

From author's summary

2793. Venkata Rao, B. N., The design of machinery foundations with special reference to the vibration problem, *J. Instn. Engrs., India* **37**, 3, 217–240, Nov. 1956.

Paper briefly discusses some of the factors, like vibration of machinery and foundations, methods adopted for minimizing the transmission of vibration to bodies external to the foundation, etc., involved in the safe and economical design of machine foundations. The design procedure is illustrated by a worked example and a list of empirical formulas for determining the foundation sizes of reciprocating machines is given.

From author's summary

2794. Geiger, J., On dynamical forces in turbine foundations (in German), *Beton u. Stahlbeton.* **51**, 4, 86–88, Apr. 1956.

2795. Corbetta, G., Critical region of torsional vibration (in Italian), *Ingegnere* **30**, 2, 153–161, Feb. 1956.

2796. Marquard, E., Calculation of vibration of bridges under the influence of rolling loads (in German), *Ing.-Arch.* **23**, 1, 19–35, 1955.

2797. Kawasumi, H., Notes on the theory of vibration analyser, *Bull. Earthq. Res. Inst., Tokyo Univ.* **34**, 1, 1–8, Mar. 1956.

Notes are given on basic theory of vibration analyzers, with special reference to problem of spectrum of seismic waves and engineering seismology. Cases of no damping and finite damping are considered, and applied force-functions of various special forms are included. Both continuous and line spectra are considered. Comment is made to G. W. Housner's work on earthquake spectra. K. E. Bullen, Australia

2798. Lin, T. H., The effect of spring mass on contact-accelerometer responses, *J. appl. Mech.* **23**, 3, 385–389, Sept. 1956.

Theoretical responses of a contact-break accelerometer are analyzed for steady-state and some transient motions. The distributed mass of the spring is considered in the present analysis. For steady-state motions, viscous damping is assumed to exist between the spring and the case of the instrument. Responses to simple harmonic motions of different frequencies are shown. Responses to a single cosine wave and a step function of acceleration are analyzed. The main source of error in the contact-break accelerometer is shown to be due to the spring mass. An electromagnetic contact with no spring mass is proposed. Preliminary study of this accelerometer is shown.

From author's summary by P. G. Jones, USA

Wave Motion in Solids, Impact

(See also Revs. 2783, 2787)

2799. Abramson, H. N., Flexural waves in elastic beams of circular cross section, *J. acoust. Soc. Amer.* **29**, 1, 42–46, Jan. 1957.

Paper deals with the flexural vibrations of long, elastic circular cylinders, using the exact equations of motion of an elastic solid in the appropriate form: the Pochhammer-Chree equations. The problem was first discussed by G. E. Hudson [*Phys. Rev.* **63**, 46-51, 1943] who gave numerical solutions for the frequency equation, connecting phase velocity, wave length, the radius of the cylinder and the constants of the material; it was stated that the frequency equation has only one root, which implies that sinusoidal, monochromatic flexural waves can only be propagated in a single mode.

Author shows that this result is incorrect, and he gives curves representing the numerical solutions for the three lowest roots of the frequency equation together with the related group velocity curves for two of the modes.

Hudson's error has been repeated in the literature and the reviewer, among others, must plead guilty to the charge of disseminating it. R. M. Davies, USA

2800. Cheney, J. A., Structural analysis by dynamic load parameters, *J. Amer. Concr. Inst.* **28**, 1, 99–111, July 1956.

Paper summarizes the method of normal modes which may be used in the analysis of structures under blast and earthquake excitation. Solutions are simplified to give equations involving several basic nondimensional parameters. The equation which applies to all structural problems solved by the method of normal modes is:

$$\text{Deflection} = C \sum_{i=1}^{N} \frac{\left[\begin{matrix}\text{Characteristic}\\ \text{Function}\end{matrix}\right] \left[\begin{matrix}\text{Participation}\\ \text{Factor}\end{matrix}\right] \left[\begin{matrix}\text{Dynamic}\\ \text{Load Factor}\end{matrix}\right]}{\left[\begin{matrix}\text{Characteristic}\\ \text{Number}\end{matrix}\right]}$$

The bracketed terms are nondimensional factors, the C-term carrying the required dimensions. Application is made to a reinforced-concrete building under earthquake and blast loading.

From author's summary

2801. Shil'krut, D. I., Propagation velocity of elastic waves in an imperfectly elastic medium (speed of a signal) (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **106**, 1, 58–60, Jan. 1956.

2802. Chow, T.-S., Remarks on the convergence of an iterative procedure in solving dynamic response problems, *J. aero. Sci.* **23**, 12, 1119–1120 (Readers' Forum), Dec. 1956.

2803. Goldsmith, W., and Cunningham, D. M., An experimental investigation of the oblique impact of spheres upon simply supported steel beams, *Proc. Soc. exp. Stress Anal.* **14**, 1, 171–180, 1956.

A comprehensive program of study concerning the impact of spheres upon simply supported beams at oblique angles of incidence has been initiated. The initial impact velocity of 150 fps for a ½-in. diam steel ball is such as to generate permanent indentation at the contact point. Present paper describes the equipment and instrumentation employed in the investigation as well as the results obtained for a typical test run. The experimental data permit the construction of the complete stress and deflection history of the beam and the trajectory of the ball, including the contour and topography of the groove created at the impact point. Quantitative information concerning the propagation of the flexural waves, the excitation of mode frequencies, and the amplitude of the displacement and stresses produced in the beam are derived from test results. The analysis of the data is based upon a resolu-

tion of the resultant forces into components normal and tangential to the beam.

The compilation of results from one hundred thirty test runs and correlation of this information with theoretical considerations will be reported subsequently. From authors' summary

2804. Edge, P. M., Jr., Impact-loads investigation of chine-immersed models having concave-convex transverse shape and straight or curved keel lines, *NACA TN* 3940, 66 pp., Feb. 1957.

As part of an investigation of hydrodynamic impact loads on chine-immersed bodies of heavy beam loading, three narrow-beam models of concave-convex transverse shape and having, respectively, a straight keel, a curved bow, and a curved stern were tested at the Langley impact basin. The tests were made over a wide range of trim and initial-flight-path angles. Most of the landing impacts were made at a beam-loading coefficient of 18.77, with a few impacts at beam-loading coefficients of 27.39 and 36.15. The investigation was conducted primarily in smooth water; however, a few impacts with the curved bow were made in rough water.

The impact-loads data are presented in tables, and the derived coefficients of loads and motions are presented in figures as the variation with initial-flight-path angle. The experimental effects of transverse and longitudinal curvatures agree reasonably well with those predicted by theory. The concave-convex bottom, which was similar to shapes considered as being of constant-force type, yields slightly higher peak loads than a narrow-beam model having conventional vee bottom of equivalent angle of dead rise, with the possible exception of certain rough-water-impact conditions. The effect of stern curvature for the configurations tested is greater than the effect of bow curvature. The rough-water loads were found to be much greater than smooth-water loads for similar initial impact conditions and were in reasonable agreement with loads obtained from theory when the flight-path angle, velocity, and trim angle relative to the wave slope were used.

From author's summary

Elasticity Theory

(See also Revs. 2783, 2823, 2829, 2831, 2843, 2845, 2853, 2866, 2877, 2886, 2934, 3093)

2805. Naleszkiewicz, J., Energy levels in dynamics of elastic system, *Arch. Mech. stos.* **8,** 4, 471–506, 1956.

Author has shown in his previous papers [AMR **9,** Revs. 435, 436] that, in the problems of nonlinear elastic stability, there exist phenomena which can be described in terms of quantum mechanics.

In this paper a system of one degree of freedom subjected to damping is discussed. Detailed discussion of the dependency of the energy levels on the deflection angle leads to the conclusion that a vibrating system can be stopped in a position of stable equilibrium of higher potential energy than in the fundamental position.

The second system represents a prismatic bar loaded at both ends by bending moments, with twisting moment and axial force. Because of numerous independent parameters and the difficulty of general discussion, author reduces the analysis of vibration stability types for some values of the parameters. The analysis is based on a graphical demonstration of the frequency of free vibrations in function of two parameters of the system, the other parameters being constant.

Certain chapters of author's previous papers concerning the same subject are summarized. M. Piatek, Poland

2806. Kilchevskii, N. A., Investigations of certain problems of the theory of elasticity (in Russian), *Bulletin of Kiev Polytechnic Institute* **15,** 96–111, 1954; *Ref. Zh. Mekh.* 1956, Rev. no. 3025.

Article is a survey of author's works in the sphere of statics and dynamics of elastic thin films and contact problems of the theory of elasticity.

The following are the most important results.

(1) General calculation of reducing a three-dimensional problem of the theory of films to a two-dimensional one.

(2) An approximate method for solving the static problem of this theory, based on the theorem of reciprocity of work.

(3) The method for solving the dynamic problems by means of reducing them to static ones in space of Laplace representations of functions of the dynamic problem. The effectiveness of this method when applied to films is dependent upon the fact that a theorem on the reciprocity of work occurs in the space of representations.

The equations which express this theorem supply a system of functional equations for representations. In this connection, certain problems not completely solved of the existence and singularity of solutions, of the accuracy of the approximate methods, and certain other ones occur. It is pointed out that the question of concentration of the dynamic stresses near orifices has hardly been examined. The method based on the Laplace transformations proved very effective when applied to the dynamic contact problem examined in author's monograph "Theory of the co-impacts of solid bodies" [Gostekhizdat 1949].

In the article, a new basis for the relationship

$$a^* = kP^{*2/5}$$

is adduced between the initial displacement a^* and the force $P^{*2/5}$ in the representation space, which was put forward as a probable hypothesis in the monograph. N. A. Rostovtsev, USSR

Courtesy Referativnyi Zhurnal

Translation, courtesy Ministry of Supply, England

2807. Arzhanykh, I. S., Representation of the static displacement vector of an elastic body by independent harmonic functions (in Russian), *Report of Acad. of Sciences of Uzbekistan SSR* no. 8, 3–7, 1954; *Ref. Zh. Mekh.* 1956, Rev. no. 3026.

The problem is examined of the general solution of the Lamé equation

$$(\lambda + 2\mu)\ \text{grad div}\ \bar{u} - \mu\ \text{rot rot}\ \bar{u} = \bar{F} \qquad [1]$$

$\bar{u}$ is a displacements vector, $\bar{F}$ vector of volume forces, μ, λ are Lamé constants.

The general solution can be written in the form

$$\bar{u} = \bar{A} + \bar{B} - \alpha\,\text{rot}\,[rA] - \beta\ \text{grad}\ (\bar{rB}) \qquad [2]$$

$$\gamma\nabla^2\bar{A} = \bar{F} + \beta\,\bar{r}\ \text{div}\ \bar{F}$$

$$\gamma\nabla^2 B = \bar{F} + \alpha[\bar{r}\ \text{rot}\ \bar{F}]$$

$$\alpha = \frac{\lambda+\mu}{2\mu}, \quad \beta = \frac{\lambda+\mu}{2(\lambda+2\mu)}, \quad \gamma = \tfrac{1}{2}(3\lambda + 7\mu)$$

In the case of the absence of volume forces the vectors $\bar{A}$ and $\bar{B}$ which enter into [2] are harmonic, and the general solution contains six harmonic functions.

Further, the author notes that, for the solution of three-dimensional problems of the theory of elasticity, it is possible to put three of the six harmonic functions which enter in [2] equal to zero. As was shown in the work of the abstractor [See *Ref. Zh. Mekh.* 1954, Rev. 4872], the problem of the generality of one or the other form of solution expressed by three harmonic functions, requires special examination and also depends essentially upon the cohesion of the generality. M. G. Slobodyanskii, USSR

Courtesy Referativnyi Zhurnal

Translation, courtesy Ministry of Supply, England

2808. Neuber, H., An exact solution for the stress distribution in notches with arbitrary values of depth and notch angle (in German), *Forsch. Geb. Ing-Wes.* **23,** 1/2, 9–10, 1957.

Author finds an exact solution for the stress concentration factor of notched bars, which reduces to simple expressions for arbitrarily deep notches of small radii of curvature. For elaboration, reader is referred to new edition of author's well-known book.

W. Freiberger, USA

2809. Krishman, S., Stress distribution in thin-walled wide-flanged beams, *J. aero. Soc. India* **9,** 4, 81–87, Nov. 1956.

Analysis is presented for simple beams with concentrated, uniform, and triangular loadings. Beam proportions are assumed such that bending and buckling plate effects of flanges are not significant. Flange is then treated as a two-dimensional elasticity problem with stress function in form of trigonometric series. Series coefficients and Lagrange multiplier introduced by displacement boundary condition are found using Raleigh-Ritz minimum energy method.

Tables of coefficients for first seven terms of trigonometric series are given for ratios of beam length to semi-flange width from 6 to 30. Curves are provided of stress variation, equipment flange width, and checks with two prior solutions of problem.

C. M. Tyler, Jr., USA

2810. Renzulli, T., Problems related to the stability of equilibrium in a field of nonlinear elasticity (in Italian), *G. Gen. civ.* **94,** 7/8, 478–486, July/Aug. 1956.

Paper gives an energy treatment of some simple problems of nonlinear elastic stability. The nonlinearity is due to the presence of quadratic stress terms in the stress-strain relationships. The problems all relate to rectangular-shaped, uniform, straight beams, freely pivoted at their ends. In the cases considered, instability is due to (1) compressive end load, applied either centrally or eccentrically and (2) end bending couples. Some illustrative numerical examples, with data appropriate to concrete, are worked.

H. G. Hopkins, England

2811. Kauderer, H., A nonlinear elasticity equation and its application (in German), Deformation and flow of solids, Colloquium Madrid, Sept. 26–30, 1955, 187–202, Berlin, Springer Verlag, 1956.

Author discusses origin of nonlinear terms in classical elasticity theory. He considers a completely elastic homogeneous isotropic material in which hydrostatic strain is determined solely by hydrostatic stress, and the shear strain tensor is determined solely by shear stress, and where the elastic moduli are not constant but are expressible as power-series functions of strain. For this material he derives equations for the stress components in terms of the strain components, and conversely.

He applies these equations to four examples: a twisted cylinder, an end-loaded cantilever, a hollow sphere under internal pressure, and a circular plate loaded at its edge. Taking measured (nonlinear) elastic data for Cu and for Al-bronze, he calculates the stresses in these examples, and finds that they may be as much as 50% different from the stresses calculated assuming linear elasticity.

R. L. Woolley, Iraq

2812. Davin, M., Statistical study of the strength of prismatic bodies under action of a uniform field of forces (in French), *Ann. Ponts Chauss.* no. 6, 519–754, Nov./Dec. 1956.

The problem of local weakening of materials is approached statistically. Considering the strength as being random variable, it was shown through theoretical analysis, and verified experimentally on concrete slabs, that the distribution function obeys the so-called laws of extremes (introduced by Fisher and Tippett, and used in conjunction with strength of materials by Weibull and Gumbell), rather than the normal distribution.

A question of the size effect for ideally brittle materials was studied, and a suggestion was put forward as to how to attack a similar problem for ideally plastic materials.

R. M. Evan-Iwanowski, USA

2813. Kuznetsov, V. I., Calculation of structures on an elastic semi-space (in Russian), *Tr. Mosk. vecb. masbinostr. in-ta* no. 1 141–189, 1953; *Ref. Zb. Mekb.*, 1956, Rev. no. 3072.

Paper is devoted to problems of calculation of beams and circular plates on an elastic base. It is divided into a series of small chapters which are not numbered. In the first chapters which are devoted to the calculation of beams, author, starting from G. E. Proktor's hypothesis, introduces integral equations for various cases of loading. Proktor's hypothesis is that pressure under the beam in a transverse direction is constant. It was determined in investigations by L. A. Galin and M. I. Gorbunov-Posadov that the pressure under a long rigid beam in a transverse direction varies similarly to that under a rigid strip [see M. I. Gorbunov-Posadov, "Calculation of constructions on an elastic base," 1953, pp. 368, 378, 433; L. A. Galin, "Contact problems of the theory of elasticity," pp. 235–245].

Author transforms the integral differential equation of the curved axis of a beam by fourfold repeated integration to Fredholm's integral equation of the second kind with a nucleus having a logarithmic characteristic. It was demonstrated how it is possible to consider (fairly conventionally) the action of the transverse force and the transverse compressing stresses.

A nonlinear integral equation has been derived for the case of considerable bending.

In the chapter "General expansion of an integral equation," the author, attempting probably to effect a compromise between Winkler's hypothesis and the hypothesis of elastic basis, makes a mistake putting

$$p(\xi) = c\omega(\xi) = c \int_{-1}^{+1} p(t)\ \operatorname{arsh} \frac{\Delta}{|\xi - t|}\ dt \qquad [24]$$

(Δ is a constant, equal to the relationship of the width of the beam to its length). Likewise $p(\xi)$, the pressure along the beam, is the solution of the homogeneous integral Eq. [24] and is equal, consequently, to zero in the case of arbitrary values of the coefficient c, with the exception of those which are natural numbers. However, in the latter case also, $p(\xi)$ proves to be a completely determined function ξ, independent of the method of loading $q = q(\xi)$. The mistake in question lessens the value of the further computation in this chapter.

In the chapter "Methods of solving integral equations," certain known methods of the numerical solution of these equations are described. For the purpose of illustration in table form the diagrams of reaction pressures for certain cases of loading are given. The comparison made by the abstractor for the case of uniform loading with the diagrams of M. I. Gorbunov-Posadov shows negligible differences in the middle of the beam and fairly considerable ones at the ends, where, as is known, none of the approximate methods is able to give satisfactory results.

Then a precise solution is given of the axial symmetrical problem of bending an infinite thin plate on an elastic semispace. The reaction pressures and settling are expressed by integrals from cylindrical functions similar to O. Ya. Shekter's integrals, the works of whom are not mentioned in this connection. In particular, Eq. [51] of pressure in the center of the plate with a concentrated load belongs to Shekhter [M. I. Gorbunov-Posadov, ibid, p. 188].

There are numerous misprints in the work, including some in the equations. The Bessel functions $J_n(x)$ are in all cases written $I_n(x)$.

N. A. Rostovtsev, USSR

Courtesy Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

2814. Levi, F., Theory of a thin cylindrical shell (in Italian), *G. Gen. civ.* **94,** 9, 593–610, Sept. 1956; **94,** 10, 662–677, Oct. 1956.

In the theory of a thin cylindrical shell, compatibility equations were found, starting from different positions, by Jakobsen, ASCE, Finsterwalder, Jenkins, and Schörer.

Author compares the different hypotheses and numerical results, concluding that different positions always give a smaller difference in results when the boundary conditions are stated in a more accurate manner. It would be useful to extend a similar comparison to Zanaboni's theory [see *Atti della Accad. Naz. dei Lincei*, **28**, 85–91, 1936]. G. Supino, Italy

2815. Föppl, L., Theory of the two-dimensional stress state in new representation (in German) *Forsch. Geb. Ing.-Wes.* **22**, 5, 141–146, Sept. 1956.

In reviewer's opinion, paper contains nothing new. The subject matter has been exhaustively studied by various authors and the content of the present paper is contained in N. I. Muskhelisvili's treatise, "Some basic problems of the mathematical theory of elasticity," Groningen, 1953 [AMR **7**, Rev. 2099], which pioneered the ideas in this paper. J. Brandstatter, USA

2816. Grinberg, G. A., Pokruvskii, A. N., and Vfliand, Ya. S., Characteristic state of stress of an elastic thin wedge-shaped plate with a fixed and a free side (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* **22**, 193–198, 1955.

The problem of characterizing the state of stress in an infinite elastic thin wedge-shaped plate of angle α is solved. In particular, for a concentrated load acting at an arbitrary point of the wedge and subject to boundary conditions stated in the title, an explicit solution is obtained.

The method of solution utilizes the techniques of the Mellin transform, and the solution is exhibited in the form of an integral in the complex domain along a suitable path. Explicit results are tabulated for the moment per unit load and for various values of the wedge angle α and Poisson's ratio. It is indicated how to extend the solution for an arbitrary load.

J. Brandstatter, USA

2817. Payne, L. E., On a class of plane and axially symmetric problems in elasticity, Proc. First Congress on Theoretical and Applied Mechanics, Nov. 1–2, 1955, 1–8, Kharagpur, Indian Inst. of Technology.

The following plane and axially symmetric problems are treated in a unified manner by reducing them to problems in classical potential theory: (a) when stresses, displacements, or a combination of the two, are given on the boundary of either a semi-infinite region or an infinite strip, (b) when the medium has certain elastic symmetries, and (c) when point forces act at specified interior points. The technique makes it possible to avoid the dual integral equations of transform methods and yields the complete stress distribution in readily accessible form. H. D. Block, USA

2818. Boley, B. A., The calculation of thermoelastic beam deflections by the principle of virtual work, *J. aero. Sci.* **24**, 2, 139–141, Feb. 1957.

An approximate formula for deflections of heated beams is compared with more exact formulas and found to be very good. The formula may be justified by the following:

If the effects of Poisson's ratio are negligible, then a longitudinal stress equal to $E \alpha T$ would be required to prevent longitudinal deformation in a heated beam. The removal of this stress (giving a stress-free result) by superposing an equal and opposite stress would, in general, superpose moments about the principal axes. The approximate formula is based upon the curvatures that would result from these moments. It will be exactly correct in case there are no resulting stresses, and should not be greatly in error when stresses result from self restraint alone.

Deflections are computed from curvatures by the aid of the principle of virtual displacements. G. Pickett, USA

2819. Dow, N. F., A re-evaluation of some air-frame thermal problems, *Aero. Engng. Rev.* **15**, 11, 61–66, Nov. 1956.

A second approximation of the significance of the problems of material selection, thermal stresses, and inelasticity or creep encountered in the air frame in supersonic flight is discussed. The conclusion is reached that, in the area of gross thermal effects on the structure, material and structural advances should keep pace with those in the fields of aerodynamics and propulsion so that progress will not be slowed by the thermal barrier.

From author's summary

2820. Horvay, G., Problems of mechanical analysis in reactor technology, ASME Nuclear Science and Engineering Conference, Cleveland, O., Dec. 1955. Preprint 355, 69 pp. + 19 figs.

The role of the structural specialist in the atomic power field is outlined, and some of his tasks at the Knolls Atomic Power Laboratory are described. Thermal stress and shock phenomena receive particular attention. Shell and perforated plate problems are also considered. The paper concludes with a brief discussion of design principles. From author's summary

2821. Pant, B., Photoelastic analysis of thermal stresses for openings in structures, Proc. First Congress on Theoretical and Applied Mechanics, Nov. 1–2, 1955, 189–198, Kharagpur, Indian Inst. of Technology.

A technique for evaluating two-dimensional temperature stresses is described. Since the fringe value of the material (Hamolite) employed for the photoelastic model is temperature sensitive, it is necessary to calibrate over a range of temperatures and to measure the temperature distribution as well as the relative retardation. A further difficulty is introduced by the fact that the elastic modulus of Hamolite is also temperature sensitive. In order to reduce the discrepancy between model and prototype stress fields arising from this source, only small temperature gradients are employed. Model thickness is increased to a point at which relative retardation can be measured fairly accurately. Apart from the temperature calibration of the material, the photoelastic analysis follows conventional lines. L. E. Goodman, USA

2822. Singh, K. P., Centrifugal and thermal stresses in rotating discs, Proc. First Congress on Theoretical and Applied Mechanics, Nov. 1–2, 1955, 169–180, Kharagpur, Indian Inst. of Technology.

Author develops tabular method for solving problem. Disks of varying thickness are treated in usual manner by splitting into concentric rings, satisfying equilibrium and compatibility conditions at interfaces. Method is to introduce a peripheral load, subsequently eliminated by superposition principle between following cases:

(a) Disk stationary, peripheral tensile load;

(b) Disk rotating, peripheral compressive load;

(c) Disk stationary, subjected to temperature gradient, with peripheral compressive load.

In cases (b) and (c), compressive load is determined by making stresses zero at bore, which is starting point for method. By superposition of case (a), stresses are determined.

Reviewer considers accuracy of method could be improved by allowing for temperature variation across each ring; otherwise, a large number of rings should be taken. Also, introduction of fictitious peripheral load is superfluous [see Donath's method using Grammel's transformation, outlined in "Steam and gas turbine" by A. Stodola]. There are several minor typographical errors, and, although author includes useful worked example, this could have been improved by making it suitable for a computer without special knowledge of elasticity. J. M. Alexander, England

Experimental Stress Analysis

(See Revs. 2821, 2893)

Rods, Beams, Cables, Machine Elements

(See also Revs. 2766, 2785, 2787, 2790, 2803, 2804, 2809, 2810, 2811, 2813, 2818, 2868, 2884, 2890, 2893, 2897, 2908)

2823. Jones, E. E., Finite Fourier transform analysis of the flexture of a non-uniform beam, *J. roy. aero. Soc.* **60,** 552, 805–806 (Technical Notes), Dec. 1956.

Author presents an analytical method of calculating bending moments and deflections of a nonuniform beam under arbitrary transverse loading and variable flexural rigidity by an amplification of Strandhagen's method. Application of finite Fourier sine and cosine transforms permits analytical representation of flexure under any end conditions of the beam. Two examples are given.

Reviewer points out that this method may also be useful in computation of plates and shells considering conditions of compatibility between border girder and superficies.

H. Beer, Austria

2824. Schulz, M., and Chedraui, M., Tables for circularly curved horizontal beams with symmetrical uniform loads, *J. Amer. Concr. Inst.* **28,** 11, 1033–1040, May 1957.

These tables will simplify and expedite the engineer's task of calculating circular beams without developing the formulas. Step-by-step derivation of the tables is given.

From authors' summary

2825. Holmberg, A., Load capacity of concrete beams in bending, *J. Amer. Concr. Inst.* **27,** 7, 767–770, Mar. 1956.

Paper reviews past research by various investigators and arrives at two equations by which the load capacity of a concrete beam in bending may be estimated. From author's summary

2826. Arutyunyan, N. Kh., and Gulkanyan, N. O., Center of bending of certain prismatic rods with a polygonal cross section, *Appl. Math. Mecb.* **18,** 5, 597–618, 1954; *Ref. Zb. Mekh.* 1956, Rev. no. 3048.

As is known, the determination of the stress function during the bending of a prismatic rod, the cross section of which has one axis of symmetry, is reduced to the solution of the equation

$$\Delta U = \frac{P\sigma}{I(1+\sigma)}(y - y_0) - \frac{P}{2I}f'(y)$$

with the condition on the contour of the section

$$\frac{\partial U}{\partial s} = \frac{P}{2I}[x^2 - f(y)]\frac{dy}{ds}$$

In this case P is the bending force applied at the center of gravity of the free end of the rod, σ is the Poisson coefficient, y_0 is the coordinate of the center of gravity of the section, I is the axial moment of inertia of the section, and $f(y)$ is the arbitrary function, determined from conditions on the contour.

The bending center is determined according to the equation

$$y = \frac{1}{P}\iint_{\Omega}\left\{x\frac{\partial U}{\partial x} + y\frac{\partial U}{\partial y} - \frac{P}{2I}[x^2 - f(y)]\right\}dxdy$$

in which Ω is the region of the cross section of the rod.

Author reduces determination of the stress function during bending of the prismatic rods of the polygonal section to solution of the ordinary differential equations of the second order with constant coefficients; in this the values of the constant integrations are determined from completely regular infinite systems of linear equations.

Further, on the basis of the results obtained, a precise determination is given of the center of bending of prismatic rods of polygonal cross section (tee section, girder, isosceles angle bracket). A. K. Rukhadze, USSR

Courtesy Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

2827. Barta, J., On the calculation of the permissible compressive load on an elastic bar (in German), *Acta Techn. Hung. Budapest* **15,** 3/4, 443–455, 1956.

Paper contains theoretical considerations, the purpose of which is to prove the limiting process. Both ends of the bar allow free rotation. Small initial curvature of the bar and small eccentricity of the loading force are considered. The cross section of the bar is variable or constant. A numerical example shows the details of the limiting process, and use is made of the method of successive approximation. The limiting theorem is analogous to the limiting theorem of G. Temple and H. A. Schwarz.

From author's summary

2828. Mohan, R., Flexure of some composite beams, Part I. Beam having sections bounded by arcs of concentric circles and two radii, Proc. First Congress on Theoretical and Applied Mechanics, Nov. 1–2, 1955, 163–168, Kharagpur, Indian Inst. of Technology.

Using slightly modified Love's equations for bending of homogeneous bars and special flexure functions, author shows that complete solution can be obtained for the case of a load symmetrically applied at one end of the bar. No numerical examples are introduced. V. Kopriva, Czechoslovakia

2829. Sen, B. R., and Subramoniam, R., The effective width of T-beams, Proc. First Congress on Theoretical and Applied Mechanics, Nov. 1–2, 1955, 117–124, Kharagpur, Indian Inst. of Technology.

Authors remark that, in usual method for determining effective width of T beams, proper flexural rigidity of the flange is disregarded. Their purpose is to improve the theory by taking this rigidity into account. However, they disregard horizontal shear actions between flange and web of the tee beam. They solve only a very particular problem which may be defined as follows: a uniformly loaded infinitely long strip, simply supported along the two parallel edges, and moreover simply supported by a transverse elastic rib or web perpendicular to the edges.

Reviewer feels that problem may present an interest of its own but cannot be considered as a correct solution of the title problem.

C. Massonnet, Belgium

2830. Holman, D. F., A finite series solution for grillages under normal loading, *Aero. Quart.* **8,** 1, 49–57, Feb. 1957.

Reaction forces between the two sets of beams in a grillage can be expressed as linear functions of deflections at points of intersection. If deflection of one beam set is expressed by a trigonometric series, the bending moment along this set can be obtained by differentiating the series twice, as well as by a known linear function of the reaction forces, wherefore each of the constants of the series can be obtained by a finite series of the reaction forces. Author has ably shown that the infinite series for deflection of intersection points can be reduced to a finite series if the beams in the other set are equally spaced. Number of terms in series does not exceed number of beams in second set. The usual series for bending moment converging very slowly, the new exact method, when applicable, may save a considerable amount of work.

G. Vedeler, Norway

2831. Koppe, E., Nonlinear torsion of a circular cylinder (in German), *Ing.-Arch.* **25,** 1, 1–9, 1957.

Analytical and experimental treatment of torsion in which plane sections remain plane and there is no volume change. Deformation is analyzed formally in terms of the logarithmic (Hencky) strain

tensor, neglecting powers of the twist higher than the second. Analysis leads to stress distribution on the end faces. In experimental study, the normal stress on the end faces is indicated by bulging out of the (rubber) specimen at small holes in the flat end plate which delivers the stress to the rubber. This increases with the square of the twist as indicated by theory, at least for twist angles up to 5°.

The distribution across the section also agrees with theory. There is some systematic deviation from theory for larger angles of twist. S. H. Crandall, USA

2832. **Barker, A., and Jones, F. W., The reversible bending of turbine shafts with temperature,** *Proc. Instn. mech. Engrs.* **169,** 41, 853–864, 1955.

The reversible bending of certain carbon-molybdenum steam-turbine shafts is shown to be caused by expansion coefficient differences existing in the steel from which the shafts were made. This difference is a function of the heat treatment of the steel, and it is shown that the magnitude required could be obtained in shafts of the size considered by faulty normalizing conditions. A defective shaft has been cured by a second normalizing treatment in which the uniformity of the austenitizing temperature was improved. The modifications of the expansion characteristics of this steel are associated with different carbide structures.
From authors' summary

2833. **Moulton, A. E., and Turner, P. W., Rubber springs for vehicle suspension,** *Instn. mech. Engrs. Auto. Div.*, Adv. pap., 12 pp., Dec. 1956.

Authors believe that rubber is especially suitable as a suspension medium because of its intrinsic properties, and also because of the variety of forms into which it can be made, and that it will therefore take its place alongside steel springs as an accepted vehicle suspension. A research program of both field and laboratory testing has been carried out to confirm the suitability of rubber for suspension purposes, and to develop some modern forms of rubber springs.

Laboratory work included, in addition to the fatigue testing of a wide diversity of spring types, the development of a method of strain measurement for springs of irregular shape, and the determination of a basic parameter of fatigue applicable to any type of rubber spring. Service testing included the investigation of endurance characteristics, optimum values for the static deflexion, damping and low-temperature properties, permanent set and noise isolation.

As a result, authors consider that their tests have demonstrated the practicability of rubber as an automotive suspension medium, and that it can afford a simplification of the design by providing wheel location, a measure of inherent damping, and so long as the design is studied from the beginning to include rubber suspension, competitive cost in volume production. Rising rate characteristics, a degree of noise isolation and satisfactory fatigue life are readily obtained. From authors' summary

2834. **Schade, H., Contribution to the calculation of a cylindrical helical spring** (in German), *ZVDI* **98,** 35, 1927–1928, Dec. 1956.

Book—2835. **Application of spring strips to instrument design,** Nat. Phys. Lab. Notes #15; London, Her Majesty's Stationery Office, 1956, iv + 25 pp.

2836. **Bingham, A. E., Liquid springs: progress in design and application,** *Instn. mech. Engrs. Proc.* **169,** 43, 881–896, 1955.

2837. **Golling, O., Curve of a rotating cord,** *J. Instn. Engrs. Austral.* **28,** 12, 327–331, Dec. 1956.

A properly designed rotating cord may be used as a machine governor. Author analyzes such an eccentrically supported, rotating cable and obtains a solution in terms of complete and incomplete elliptic integerals. An approximate solution which can be given in terms of the complete elliptic integral is also presented. S. F. Borg, USA

2838. **Martin, G. H., Undercutting of spur gear teeth,** ASME Spring Meet., Birmingham, Ala., Apr. 1957. Pap. 57-S-3, 11 pp.

In the generation of spur gear teeth either by a hob or a gear shaper, it is known that when a relatively small number of teeth are cut a portion of the involute profile is removed. This is known as undercutting and adversely affects the performance of the gear. In this article the theory of complex functions is used to determine the amount of undercutting produced by a hob and also by a gear shaper. From author's summary

2839. **Booth, A. G., Experiences during forty years of automobile design,** Instn. mech. Engrs. Auto. Div., Preprint, 18 pp., Oct. 1956.

2840. **Wolf, M., Some considerations of Fottinger's coupling and torque converter** (in Italian), *ATA Ricerche* **9,** 7, 459–469, July 1956.

2841. **Wilke, H. L., Torque converters—a flexible drive,** ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56-A-138, 8 pp.

2842. **Hatch, T. F., The human factor in machine design,** ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56-A-46, 5 pp.

Plates, Disks, Shells, Membranes

(See also Revs. 2788, 2799, 2813, 2814, 2816, 2817, 2822, 2870, 2871, 2872, 2873, 2881, 2897)

Book—2843. **Boobnov, I. G., Contributions to plate theory [Trudy po Teorii plastin]** (in Russian), Moscow, Gosud. Izdat. Tekh.-Teor. Lit., 1953, 423 pp., 12.70 rubles.

The work of I. G. Boobnov on plate theory is well-known to western scientists through two sources, (a) The English translation of certain of his work that appeared in the *Transactions of the Institution of Naval Architects,* 1902, and (b) frequent references to his work in S. Timoshenko's "Theory of plates and shells." Boobnov's work appeared in a total of thirty research papers together with his "Theory of structure of ships", all written in Russian.

The present volume gathers together the highlights of most of his papers and presents them in a unified form. The initial chapter presents a detailed exposition of cylindrical bending of rectangular plates. In most of these treatments stretching of the middle surface of the plate is considered. Complete as well as partial uniform loads are considered, together with several boundary conditions. Deflection and moment coefficients are presented for each of these cases.

The next chapter presents the solutions of a number of problems involving rectangular plates. First, a uniformly loaded plate having two opposite edges simply supported, one edge free, and the fourth edge clamped is treated. Deflection and moment coefficients are presented for various aspect ratios of the plate. Next, stresses and deflections in a clamped rectangular plate subject to a uniformly distributed load are determined. Rectangular plates with a variety of boundary conditions and subject to simultaneous normal load and tensile or compressive loadings in the plane of the plate are next considered. As a consequence of this, the buckling load of a compressed plate is determined (no mention is made of Bryan's solution to this problem in 1891). Lastly, the buckling of simply supported rectangular plates subject

to combined bending and compression in the plane of the plate is considered.

The last one-quarter of the book presents a detailed biography of Boobnov (1872–1919) with emphasis on his contributions to the field of naval architecture. The book concludes with a listing of Boobnov's published research. Although most of these original papers are unobtainable to western readers, the current volume evidently presents the important aspects of each. However, it is to be remarked that the important results of Boobnov's work may be found in either aforementioned (a) or (b), although the present volume is considerably more detailed and present studies of some additional loadings and boundary conditions other than may be found in either of these sources. W. A. Nash, USA

2844. Nachbar, W., Bending of a rectangular plate with one free edge, *Proc. Amer. Soc. civ. Engrs.* **83,** (*J. Engng. Mech. Div.*), EM 2, Pap. 1196, 46 pp., Apr. 1957.

The plate under discussion is simply supported along three edges and free along the fourth; the lateral pressure on the plate is uniform in a direction parallel to the free edge but can vary linearly in a direction normal to it. Solution in series form is derived on the basis of the classical elastic theory. Extensive numerical results obtained on a digital computer are presented for deflections, moments, shear and reaction forces for the two cases of uniform and triangular loading. Y. Y. Yu, USA

2845. Bassali, W. A., Transverse bending of infinite and semi-infinite thin elastic plates. I, *Proc. Camb. phil. Soc.* **53,** 1, 248–255, Jan. 1957.

A form of the plate boundary condition defining certain types of boundary constraint, including the rigidly clamped and hinged boundaries, has been introduced by the author and Dawoud [AMR **9,** Rev. 3557]. In this paper, the complex variable method is applied to find the appropriate complex potentials and deflection of an infinite thin plate with an inner circular boundary subject to this boundary condition, with outer edge free, and loaded over a circular patch, the load being symmetrical with respect to the center of this patch. The limiting case in which the circular boundary degenerates to a straight line with clamped boundary condition is also considered.

The solutions given are based on the classical theory of bending of thin plates and are exact within the assumptions underlying this theory. In general, the solution contains an infiuite series. For clamped boundary condition the solution is in closed form.

G. C. K. Yeh, USA

2846. Woinowsky-Krieger, S., Bending of orthotropic plates through individual loads (in German), *Ing.-Arch.* **25,** 2, 90–99, 1957.

Solutions for rectangular plates with free boundaries in the neighborhood of a concentrated load and in the center of gravity of a loaded surface have been given. The case of a ribbed plate and the case when one end is fixed have also been discussed.

Results have been obtained in closed forms which are more advantageous than those of Huber's (reference cited in the paper) where solutions were in the form of Fourier's series converging slowly near the loading point. S. C. Das, India

2847. Subcommittee II, ACI Committee 325, Considerations in the selection of slab dimensions, *J. Amer. Concr. Inst.* **28,** 5, 433–454, Nov. 1956.

2848. Symonds, M. F., Minimum weight design of a simply supported transversely stiffened plate loaded in shear, *J. aero. Sci.* **23,** 7, 685–693, July 1956.

A method is developed for the minimum weight design of a simply supported transversely stiffened plate loaded in shear. Curves of the optimum plate shear stress, optimum critical shear stress coefficient, optimum area of stiffener, optimum average plate-stiffener shear stress, and optimum average plate-stiffener thickness are plotted against the structural index for three values of the ratio of stiffener spacing to plate depth. The effect of plasticity is illustrated by the use of a specific material, 24S-T3 aluminum alloy. In general, minimum weight design is obtained by using closely spaced stiffeners.

From author's summary by C. C. Wan, USA

2849. Elstner, R. C., and Hognestad, E., Shearing strength of reinforced concrete slabs, *J. Amer. Concr. Inst.* **28,** 1, 29–58, July 1956.

Presented as a research report without practical design recommendations, this paper reports the methods and results of experimental work on the shearing strength of reinforced-concrete slabs subjected to a centrally located, concentrated load. Tests of thirty-nine 6-ft square slabs are reported. For 34 slabs, final failure was in shear by the column punching through the slab, in most cases after initial yielding of the tension reinforcement.

Major variables were: concrete strength, percentage of tension reinforcement, percentage of compression reinforcement, size of column, conditions of support and loading, distribution of tension reinforcement, and amount and position of shear reinforcement.

The test findings show that the shearing strength of slabs is a function of concrete strength as well as several other variables. An ultimate strength theory was developed, by which the slab behavior under load may be explained and the measured ultimate loads may be predicted with satisfactory accuracy.

From authors' summary

2850. Durelli, A. J., and Barriage, J., The stress distribution in square plates with hydrostatically loaded central circular holes (in Spanish), *Cienc. y Tecn.* **121,** 609, 16–25, May 1956.

The stress distribution in square plates with hydrostatically loaded central circular holes was determined using photoelasticity and brittle coatings.

Photoelasticity was used to determine the maximum shear lines (isochromatics) and a brittle coating was used to determine the direction of the principal stresses (isostatics). The investigation was conducted for plates with holes producing seven ratios of the diameter to the square side (D/a).

Curves are presented which show the distribution of the maximum shear stress along the axis and along the diagonal of the square plate, as a function of D/a (figs. 4 and 5). The maximum principal stress along the exterior and interior boundaries as a function of D/a (figs. 6 and 7) has also been given.

A comparison is made of the stress ratios (σ_1/P) at a point on the axis of the square at the interior boundary with that calculated for a thick wall cylinder using Lame's equation (fig. 8). Stress ratios (σ_1/P) are also determined for a point on the diagonal of the square plate at the interior boundary (fig. 9).

A diffused light polariscope was used. The loading jig consisted of rubber tubing in a grover block. The photoelastic material (CR 39) was calibrated automatically. No new methods are developed in the paper, but it is felt that the use of the presently available methods has been simplified appreciably.

From authors' summary

2851. Gurevich, S. G., Stress distribution in a rectangular plate arbitrarily loaded at its edges (in Russian), *Bull. Leningrad Electrotechnical Institute* no. 27, 77–122, 1955; *Ref. Zh. Mekh.* 1956, Rev. no. 3070.

The problem is solved of the elastically stressed state of a rectangular plate. The stresses are applied at the edges of the plate and represent fragmentary continuous functions. The solution is based on the work of A. I. Lurier ["Theory of thick plates," *Math. Mech.* **6,** 1942]. The calculation is reduced to solution of an infinite system of equations. Author confines himself to a finite

number of equations. A considerable portion of the calculation is tabulated. N. S. Kurdin, USSR

Courtesy Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

2852. German, D. Ya., and Prokopiv, V. K., Bending of a uniformly distributed load on sector plates with an encastraed circular edge (in Russian), *Engineering collection* **21**, 120–127, 1955; *Ref. Zh. Mekh.* 1956, Rev. no. 3074.

A solution is given of the problem of bending of sector plates with an encastraed circular edge and free rectilinear borders under the action of a uniformly distributed load. Uniform solutions of a biharmonic equation are used. The boundary conditions on the rectilinear borders of the plate are accurately fulfilled; following the method indicated in the work, the border conditions on the arc edge may be satisfied with the given degree of accuracy. Two particular values of the sector angle of 120° and 180° are brought to a numerical result represented in the form of stress graphs. In addition, the stress state is examined in sector plates under the action of concentrated force at the apex. The numerical calculation is performed for a sector plate with an angle in the case of an apex of 120°. I. E. Sakharov, USSR

Courtesy Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

2853. Podstrigach, Ya. S., The stresses about two unequal apertures in a two-dimensional field (in Russian), *Naucb. zap. in-ta mashinoved. i avtomatiki, Akad. Nauk USSR, ser. Mashinoved* 4, 3, 60–71, 1955; *Ref. Zh. Mekh.* 1956, Rev. no. 1611.

The stress condition is investigated of an elastic, isotropic plate of infinite extent, weakened by two unequal, circular openings (cutouts). It is assumed that normal and tangential stresses act on the boundaries of the openings, and are in equilibrium of each contour.

Introducing the bipolar coordinates ξ and η, associated with the representation (projection)

$$z = -\operatorname{acth}\frac{i\zeta}{2} \quad (\zeta = \xi + i\eta), \qquad [1]$$

author transforms the biharmonic equation for the stress functions U into the equation

$$\left[\frac{\partial^4}{\partial\eta^4} + 2\frac{\partial^4}{\partial\eta^2\partial\xi^2} + \frac{\partial^4}{\partial\xi^4} - 2\frac{\partial^2}{\partial\eta^2} + 2\frac{\partial^2}{\partial\xi^2} + 1\right](gU) = 0 \qquad [2]$$

with reference to the function gU, where g is the first differential parameter of the bipolar system of coordinates.

The solution of Eq. (2) is found by the author in the form

$$\frac{1}{a}gU = D_1\eta\, ch\,\eta + K(ch\,\eta - \cos\xi)\,ln(ch\,\eta - \cos\xi) + \sum_1^\infty f_n(\eta)\cos n\xi \qquad [3]$$

where

$$f_n(\eta) \equiv A_n\, ch(n+1)\eta + B_n\, ch(n-1)\eta + C_n\, sh(n+1)\eta +$$

$$f_2(\eta) \equiv A_1\, ch2\eta + B_1 + C_1\, sh\,2\eta - D_1\eta$$

Assuming further that the forces on the contour are expanded into series

$$\sigma_\eta^{(i)} = \sum_\sigma^\infty \sigma_n^{(i)}\cos n\xi,\ r_{\xi\eta}^{(i)}\sin n\xi \quad (i = 1, 2) \qquad [4]$$

and applying the known relationships associating the stress components σ_ξ, σ_η, and $r_{\xi\eta}$ with the function gU in bipolar coordinates, the author, from the conditions on the contours and the condition at infinity

$$(gU)_\infty = 0$$

arrives at a system for determing the constants A_n, B_n, C_n, D_n, and K.

The case is investigated in detail when a uniform pressure is applied on the contour of each opening, and the case of multilateral tension at infinity. A. K. Rukhadze, USSR

Courtesy of Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

2854. Joga Rao, C. V., Long rectangular plates subjected to line loads, Proc. First Congress on Theoretical and Applied Mechanics, Nov. 1–2, 1955, 65–86. Kharagpur, Indian Inst. of Technology.

Author solves title problem for the cases of simply supported and clamped edges under condition that long edges of plate are prevented from moving toward each other during bending. Author uses similar procedure, and presents similar graphs for numerical solutions to those appearing in chap. I. Art. 2 and 3, of Timoshenko's "Theory of plates and shells" for the case of a uniformly loaded long rectangular plate. Numerical examples are worked out for each edge condition.

R. E. Beckett, USA

2855. Seth, B. R., Bending of T-plate, Proc. First Congress on Theoretical and Applied Mechanics, Nov. 1–2, 1955, 87–90, Kharapur, Indian Inst. of Technology.

The bending of a simply supported rectangular plate can be solved if the corresponding torsion solution is known. Author uses results obtained by Basilwitsch for the torsion of a T-section to obtain the deflection in a simply supported T-plate subjected to uniform loading. D. M. A. Legatt, England

2856. Englebreth, K., Numerical calculation of the bending moments along the intermediate supports between the spans of a continuous plate (in Swedish), *Tekn. Skr.* no. 13 N, 9 pp., 1955.

Paper deals with numerical calculation of the bending moments along the intermediate supports between the spans of a continuous plate. The individual plates are rectangular in shape, and the edges are free to rotate but are otherwise immovable. The whole plate is continuous only in a longitudinal direction, the system consisting of a single row of plates all of like size and flexural rigidity. First the *average* angular deflections along an edge are numerically calculated on the basis of E. Forslind's equations, Maurice Levy's solutions being used. The load is either in the form of moments uniformly distributed along the edges, or is uniformly distributed laterally. Calculations have been made for different side ratios. Expressions are given for *average* values of bending moments for variously distributed loads. Each individual span is uniformly loaded, and calculations are given for a plate continuous over two, three, or an infinite number of spans. Next, the bending moments along the intermediate supports are calculated for different side ratios. The numerical values of the moment coefficients are given in tabular form.

From author's summary

2857. Matildi, P., Calculation of a rectangular plate cantilevered at the edge and uniformly loaded (in Italian), *Atti Inst. Sci. Constr. Pubbl.* no. 38, 19 pp., 1954/55.

2858. Palmer, P. J., and Redshaw, S. C., Experiments with an electrical analogue for the extension and flexure of flat plates, *Aero. Quart.* **6**, 1, 13–30, Feb. 1955.

Details of the design, construction, and use of an electrical resistance network for solving certain of the problems encountered in the flexure and extension of flat plates are given. Some typical experiments have been carried out with the aid of this network and the method of operation of the analogy is described. The results of these experiments are presented and they are compared with the corresponding theoretical values. The comparison is as good as could be expected in view of the limitations imposed by the very coarse mesh which was used: essentially the same results would have been obtained by the exercise of a relaxation computation, using the same size of net. No practical difficulties would be encountered in building a large network having a very fine mesh.

From authors' summary

2859. Kononenko, E. S., Problem of the compression of a parallelepiped between rigid plates without slip (in Russian), *Sb. Issled. po. teorii sooruzbenii* no. 6, 455–468, 1954; Rev. no. 351, *Ref. Zh. Mekh.* 1956.

The object of the investigation is the solution of the mixed limiting problem of the theory of elasticity for a rectangular parallelepiped, when, on the lateral faces $x = 0$, $y = d$, $y = 0$, $y = k$, there is an absence of stresses, while on the face $z = 0$, the displacement $u = v = w = 0$, but on the face $z = h$, $u = v = 0$, $w = w_0 = \text{const.}$, w_0 having to be determined according to the given force P, which compresses the parallelepiped. The expressions of the three functions of Maxwell stress are represented with the aid series of the form

$$\sum_m \sum_n \sum_p E_{mnp} P_m(x) P_n(y) \left(1 + \sin \frac{p\pi z}{h}\right)$$

in which $P_s(\xi)$ are the so called cosine binomials. The conditions of statics are identically satisfied in volume and in the portion of the surface (at the lateral faces) in which the stresses are given (= 0). The component $\phi(x, y)$ which is added to the expression of the stress σ_z is determined in such a way that at $z = 0$ and $z = h$, the conditions imposed on the displacement w are fulfilled. The coefficients of the form E_{mnp} which enter into expressions of stress functions are determined with the aid of Castigliano's theorem. Calculations effected in the first approximation (3 indeterminate coefficients) and in the second approximation (12 indeterminate coefficients) in which the number of linear equations serving to determine the indicated coefficients is brought, for reasons of symmetry, to seven. Numerical calculations, and the plotting of the graphs, are performed for the cube ($d = k = h$).

When using Casitfliano's theorem, theoretically speaking, it is possible not to trouble to observe the geometrically marginal conditions (in this case, the conditions for the deplacements u, v at $z = 0$ and $z = h$) since they are automatically effected in a precise solution of the variation problem. However, it would be important to explain to what extent the solution plotted satisfies the conditions indicated.

A. I. Lur'e, USSR

Courtesy of Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

2860. Borg, M. F., Observations of stresses and strains near intersections of conical and cylindrical shells, *David W. Taylor Mod. Basin Rep.* 911, 65 pp., Mar. 1956.

To test theory, models of the intersection of a conical and cylindrical shell, having three different apex angles in the cone and three different ratios of thickness to cylinder diameter, were subjected to internal hydrostatic pressure, and the resulting strains at various points were measured. Careful studies were made of the unavoidable imperfections in the models. The results are in substantial agreement with the Wenk-Taylor approximate theory described in *David W. Taylor Mod. Basin Rep.* 826, and with the approximate theory of Geckeler. Comparisons are also made with other theories.

From author's summary

2861. Stevens, O. B., Contribution to the analysis of thin-walled continuous shells (in French), *Publ. int. Assn. Bridge struct. Engng.* **16**, 23–24, 1956.

Author shows that Bernoulli's hypothesis of plane sections remaining plane is satisfied for closed cylindrical shells, without taking the bending terms of shell theory into account. Further, for shells on many supports, formulas are derived for the determination of bending moments at supports.

G. Herrmann, USA

2862. Drugariyan, S. M., Approximate method for calculating cylindrical envelopes (in Russian), *Collection of scientific proceedings of Erevan Polytechnical institute* no. 9, 157–166, 1955; *Ref. Zh. Mekh.* 1956, Rev. no. 3063.

An approximate calculation is given of a circular cylindrical envelope, freely resting as regards the curvilinear edges on rigid diaphragms which are rigid in their plane and flexible from this plane, in arbitrary conditions on rectilinear edges. It is based on the method proposed by T. T. Khachaturyan [Communications of Academy of Sciences of Armenian Socialist Soviet Republic, 1949 (4)].

Author starts from equations of a cylindrical envelope in V. Z. Vlasov's form ["General theory of envelopes," Gostekhizdat, 1949]. The function φ determining the displacement stresses and moments in the sections of the envelope is sought in the form

$$\varphi = \sum_{n=1}^{\infty} \varphi_n \sin \frac{n\pi x}{a} \qquad [1]$$

in which ϕ_n represents the integral of equation

$$R^8 \varphi_n^{VIII} - 4\lambda^2 R^6 \varphi_n^{VI} + 6\lambda^4 R^4 \varphi_n^{IV} - 4\lambda^6 R^2 \varphi_n^{II} + (\lambda^8 + 4k^4\lambda^4)\varphi_n = 0 \qquad [2]$$

Here

$$\lambda = \frac{n\pi x}{a}, \quad k^4 = \frac{3(1-\sigma^2)R^2}{\delta^2}$$

R is the radius of the envelope, a is the second dimension of the envelope, σ is the Poisson coefficient, δ is the thickness of the envelope.

The general solution of the homogeneous differential equation [2] is found in the form

$$\varphi_n = \sum_{i=1}^{4} A_i Y_i + \sum_{i=1}^{4} B_i Z_i \qquad [3]$$

Here A_i and B_i are arbitrary constant integrations, Y_i and Z_i are particular integrals of equation [2]. As particular integrals Y_i and Z_i functions are selected similar to the girder functions of A. N. Krylov, connected by specific differential relationships. Further, according to the method of initial parameters, a solution is given of the problem during an arbitrary load, where the influence of the initial parameters and of the external load is allowed for by the functions of influence which are expressed by functions Y_i and Z_i.

The solution of the problem is effected, having regard to merely one term of the series [1].

Two numerical examples are examined of the calculation of a concrete cylindrical arch subjected to the action of a uniformly distributed radial load. The results of the calculations are tabulated and compared with the precise solution. The deviation from the precise solution does not exceed ± 3.5%.

E. F. Burmistrov, USSR

Courtesy Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

2863. Novatsky, V., and Mossakovsky, I., The influencing surfaces of plates having the form of a sector of a flat, circular

ring (in Russian), *Byul. polsk. Akad. Nauk Otd. IV* **1**, 3, 99–105, 1953; *Ref. Zh. Mekh.* 1956, Rev. no. 1620.

The influencing surfaces are determined for bending and torsional moments as well as for transverse forces in the bending of a plate, which is equivalent to determination of the Green functions for the aforesaid quantities. The fundamental problem is stated as the determination of the Green function for an unrestricted, wedge-shaped plate (sector of a circumference of infinitely long radius), freely supported on the edges $\varphi = 0$ and $\varphi = \alpha$, where α is the central angle of the plate.

The differential equation of the flexural surfaces of the plate

$$\nabla^2\nabla^2 u(r, \varphi) = 0$$

has been replaced by the system of differential equations

$$\nabla^2 u(r, \varphi) = (r, \varphi); \ \nabla^2 \Phi (r, \varphi) = 0$$

in which the function $\Phi (r, \varphi)$ is proportional to the sum of the bending moments $(M_r + M_\varphi)$ in the radial direction and the direction of the parallel circle. The static values for the unlimited, wedge-shaped plate, loaded by a concentrated force, and consequently their influencing surfaces, are represented by the function Φ and their derivatives.

The solutions obtained for the wedge-shaped plate are applied to the determination of the Green function for a plate in the form of a sector of a flat, circular ring. The solution for the flexural surface is represented in the form of the sum of two functions $w = w_j + w_i$. In this, w_j is the Green function for the unlimited wedge, and the function w_i represents the boundary conditions.

Three particular cases are examined:

(1) Plate in the form of a circular sector, freely supported on the edges $\varphi = 0$ and $\varphi = \alpha$ and constrained along the arc $r = R_2$.

(2) Unlimited, wedge-shaped plate the central part whereof up to the arc R_1 is absent, freely supported on the edges $\varphi = 0$ and $\varphi = \alpha$, and constrained along the arc $r = R_1$.

(3) Unlimited, wedge-shaped plate, freely supported on the edges $\varphi = 0$ and $\varphi = \alpha$ and further resting on a curvilinear support $r = R_1$. R. K. Ryayamet, USSR

Courtesy of Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

2864. Mitra, D. N., Finite elastic-plastic rotation of a circular cylinder, Proc. First Congress on Theoretical and Applied Mechanics, Nov. 1–2, 1955, 91–94, Kharagpur, Indian Inst. of Technology.

Author obtains stresses in a rotating cylinder which is partly elastic and partly plastic by using Reuss' theory pertaining to persistency of elastic strains during plastic flow. For this finite stress-strain, relations are assumed to be linear in form as given by Seth. A. M. Sengupta, India

2865. Prokopovich, I. E., The calculation of thin-walled tubes lying on separate supports (in Russian), *Sb. Trudi Odessk. gidrotekhnich. Inst.* no. 6, 32–65, 1954; Rev. no. 367, *Ref. Zh. Mekh.* 1956.

A simplified method is explained for calculating a thin-walled cylindrical tube or pipe lying or embedded on supporting contours, and partially or completely filled with a liquid. The author proceeds from the equations of V. Z. Blasov [*Prikl. Mat. Mekh.* 8, no. 5, 1944] for a cylindrical envelope, and solves them by trigonometric series. In this, many terms in the initial equations are neglected. In some formulas, Poisson's coefficient is assumed to be zero. The results of certain numerical calculations according to this method are shown. Those of these results which refer to the supported pipe are compared with A. S. Gilman's results ["Calculation of spatial constructions." Minmashstroi 1950]. The divergence is insignificant. V. M. Darevskiĭ, USSR

Courtesy of Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

Buckling Problems

(See also Revs. 2810,2882)

2866. Chapman, J. C., and Slatford, Jean, The elastic buckling of brittle columns, *Proc. Instn. civ. Engrs.* **6**, 107–125, Jan. 1957.

Paper describes a theoretical and experimental investigation of the behavior of columns or walls which are elastic in compression but brittle in tension. Where the load is concentric and the column perfectly straight, the Euler load is reached; but where the load is eccentric, failure occurs at a smaller load which depends on the elastic properties of the column. Where the eccentricity is large, a considersble length of the column is cracked over part of its cross section before the failure load is reached. The relation between failure load and eccentricity has been found theoretically, and the theory has been confirmed experimentally for a particular column. There is fair agreement between theory and some earlier experiments on brick walls.

From authors' summary by W. Wierzbicki, Poland

2867. Erickson, B., Nardo, S. V., Patel, S. A., and Hoff, N. J., An experimental investigation of the maximum loads supported by elastic columns in rapid compression tests, *Proc. Soc. exp. Stress Anal.* **14**, 1, 13–20, 1956.

The testing machine is described. Experimental results of column loads in rapid compression tests are reported. Good agreement with authors' theory [AMR **7**, Rev. 68] is indicated.

M. L. Pei, USA

2868. Pyzhenkov, I. A., On the stability of two-dimensional bending in thin-walled beams (in Russian), *Pyzhenkov. Sb. nauch. tr. Mangitogor. gornometallurg. in-ta* no. 7, 404–412, 1954; *Ref. Zh. Mekh.* 1956, Rev. no. 1689.

The two-dimensional form of loss of stability of a thin-walled single-span beam is investigated, bent by a concentrated load acting in the plane of symmetry of the beam. The forces are assumed to be proportional to one of the parameters. It is also assumed that the beam cannot rotate at the ends. The angle of rotation is approximated by a sine function. The problem is solved by the method of Bubnov and Galerkin. Two numerical examples are given. R. A. Mezhlumyan, USSR

Courtesy of Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

2869. Carlson, R. L., Time-dependent tangent modulus applied to column creep buckling, *J. appl. Mech.* **23**, 3, 390–394, Sept. 1956.

Conventional methods of creep buckling analysis require determination of history of column deflection up to collapse. In contrast to these methods, Shanley [AMR **6**, Rev. 1223] has proposed the bold hypothesis that the time-dependent tangent-modulus load can be used as an estimate of the largest load a column can carry for a given time. This load is calculated from the Euler formula with the modulus of elasticity replaced by the tangent modulus of the so-called iso-stress-strain curve—the curve, for a given time, of the strain produced by a constant stress versus that stress.

Paper under review seeks to clarify the relationship of Shanley's hypothesis to the actual behavior of creeping columns. A closely reasoned, convincing argument is presented to show that the Shanley estimate can be regarded as an approximation to a certain conservative estimate obtained by a procedure outlined in the paper. The Shanley estimate, however, can be either higher or lower than the conservative estimate it approximates and consequently may give results either higher or lower than the true column capacity.

B. Budiansky, USA

2870. Shibaoka, Y., On the buckling of an elliptic plate with clamped edge, *J. phys. Soc. Japan* **11**, 10, 1088–1091, Oct. 1956.

A formal solution in terms of Mathieu functions is obtained for the case of a uniform normal edge pressure in the plane of the

plate. The infinite determinant for the buckling load is approximated to the fourth power of the elliptic plate eccentricity. The approximate buckling loads for this case are calculated for various eccentricities and compared to the energy solution given by W. Woinovsky-Krieger, *J. appl. Mech.* **4**, p. 177, 1937.

B. E. Gatewood, USA

2871. Kirstein, A. F., and Slankard, R. C., An experimental investigation of the shell—instability, strength of a machined, ring-stiffened cylindrical shell under hydrostatic pressure (Model BR-4A), *David W. Taylor Mod. Basin Rep.* 997, 23 pp., Apr. 1956.

The effects of initial eccentricity and residual welding and rolling stresses on the buckling strength of a stiffened cylinder were investigated by tests of a machined and stress-relieved model, Model BR-4A, identical in size and material with a previously tested fabricated model, Model BR-4. The experimental collapse pressure of 550 psi for Model BR-4A agrees well with collapse pressures predicted by theory and, when compared with the collapse pressure of 390 psi for Model BR-4, indicates that initial eccentricity and residual stresses have a decided effect on the strength under external hydrostatic pressure.

From authors' summary

2872. Giangreco, E., On the instability of the equilibrium of thin shells (in French), *Publ. int. Assn. Bridge struct. Engng.* **16**, 255–274, 1956.

Author expands the equations of the general theory of thin plates and shells as given in chapter XXIV of Love's, "Mathematical theor of elasticity" to take into account second-order terms of the displacements. The resulting equations are solved for the vibrations of a thin cylindrical shell taking into account edge effects and the use of prestrained cables. Graphs show that the contribution of the second-order terms is negligible.

The dimensions of the shell are modified to approximate arches of various span angles and critical loads are thus determined approximately for arches.

N. C. Costakos, USA

2873. Grigoliuk, E. I., Loss of stability with large deflections of a closed, multilayer, conical shell under action of uniform normal surface pressure (in Russian), *Inzbener. Sbornik, Akad. Nauk SSSR* **22**, 111–119, 1955.

This is an extension of a similar problem based on small-deflection theory dealt with previously by the author. The problem is reduced to two nonlinear differential equations of second order, which are solved using Bubnov-Galerkin method. The solution provides for two values of the critical load, in conformity with the well-established buckling mechanism. In the case of homogeneous shells, results are given in tables and curves, where the non-dimensional value of critical pressure $p^0 = pb^4/E\delta^4$ is plotted versus $H^0 = H/\delta$; b radius of the shell, H its height and δ its thickness.

Comparison with the linear solution shows a considerably lower critical pressure.

J. Solvey, Australia

2874. Horne, M. R., The stanchion problem in frame structures designed according to ultimate carrying capacity, *J. Instn. Engrs. Austral.* **28**, 10–11, 253–274, Oct.-Nov. 1956.

Paper discusses the design of steel columns on the basis of ultimate capacity rather than working stresses, a subject of vital importance for application of the theory of limit design to structures involving members carrying high compression loads in addition to bending moments.

In the first part of the paper the problem is classified into different cases, depending on the kind of moment interaction between the beams and the column at the ends of the latter, both with regard to the major column axis x and the minor axis y. The condition when the bending of the column is restrained by the beam moment is called the elastic loading and is designated by the symbol E with subscripts x or y. When the bending of the column is assisted by the beam moment, there is plastic loading labelled P with the same subscripts. Finally, when the beams and the column exert no moments on each other, there is simply supported loading marked 0_x or 0_y. The 9 cases so established, designated E_xE_y, E_xP_y, etc., are discussed from the viewpoint of their significance in steel structures and their susceptibility, or lack of such, to available methods of design under conditions of ultimate capacity. Some of these cases are judged intractable to a rational design.

Further, author discusses and criticizes two existing sets of British regulations concerning column design and presents a method of his own, in lieu of them, based on an elaborate elastic analysis coupled with some assumptions. This method, suitable for cases P_x0_y, 0_xP_y, and P_xP_y, is illustrated on examples and its results are compared with the two other methods. Determination of the end moments in the column, necessary for the design, is also briefly discussed.

In view of the great practical importance of the subject matter of the paper, reviewer thinks that it is in order for him to state his two observations on the subject.

1. The alleged superiority of limit design is based on interaction of all members of the structure in the course of which the weak members are relieved by the ones situated more favorably. The author, however, proposes to design each column independently of the rest of the structure and, furthermore, while the column stresses are analyzed by elaborate formulas, the compression load and the end moments used in these formulas are found in a very crude manner. To reviewer's mind this procedure is incongruous, and, what is even more important, runs contrary to the basic principle of limit design.

2. Reviewer had difficulty in following the discussion of different column cases, and he has a feeling that the author, with extensive experience in theoretical and experimental column research, did not convey a sufficient part of this background to the readers, as if he were writing for his colleagues and not for the general audience of steel designers.

A. Hrennikoff, Canada

2875. Harris, L. A., Axial compression buckling of a pressurized cylinder with a thermally induced ring compression, *J. aero. Sci.* **23**, 12, 1120–1121 (Readers' Forum), Dec. 1956.

2876. Procter, A. N., Elastic stability under combined loading, *Engineering* **182**, 4733, 655–657, Nov. 1956.

The method of calculation given shows how an accurate estimate may be made of the buckling strength of a flexible structural member under a system of axial forces, bending moments and torques; also how the resulting secondary bending moments may be estimated. It is assumed that the properties of the materials remain approximately constant and that the cross sections of the members are such that they will not fail by local buckling. The calculations are intended to apply to "Euler" members, but they may be adapted to apply also to stiffer members. The members are assumed to be initially straight.

From author's summary

Joints and Joining Methods

STRUCTURES

(See also Revs. 2794, 2796, 2800, 2813, 2823, 2825, 2829, 2830, 2848, 2908, 2923, 3099, 3121, 3122, 3123, 3127)

Book—2877. Guldan, R., Elementary statics of construction: a text and reference [Elementare Baustatik fur Studium und Praxis], Vienna, Springer-Verlag, 1956, xvi + 295 pp. $9.30.

Book is an excellent text on statics of construction and strength of materials; it covers thoroughly the theory of statics for plane force systems, trusses, statically determinate beams, continuous beams, and simple frames. The details of the derivations are given and frequent illustrative examples are fully worked out. This is also true of the problems in graphical statics, which are prominently treated in the book.

In addition to the foregoing, however, the book approaches the usefulness of a handbook in the wealth of examples given and of tables and series of diagrams for beams and trusses under all sorts of conditions. This work should be most useful both for purposes of instruction (though no problems for the student are given) and for the practicing engineer.

B. A. Boley, USA

Book—2878. Kaufmann, W., Statics of frames [Statik der Tragwerke], Berlin, Springer-Verlag, 1957, Fourth enlarged and improved edition, viii + 327 pp.

This fourth enlarged and improved edition is a comprehensive, carefully edited introduction into the theory of structures. Chapters newly added are: Theories of failure; Torsional stresses in thin-walled open section; Vierendeel trusses; Torsionally restrained beams of deck frames; and Theory of second-order deflections applied to long span suspension and arch bridges.

The book comprises six main sections in all. First section concerns general fundamentals. In the second section author treats moments, shear and axial forces in statically determinate beams, arches and related systems. Forces in the bars of a statically determinate plane and three-dimensional framework are the subject of the third section.

In the fourth section author takes up elastic deformation: virtual displacement, reciprocity of elastic deformations, Castigliano's theorem, deflection due to bending, displacement of a framework. The fifth section includes a discussion of theory of statically indeterminate structures, including the use of a statically indeterminate base system; one unknown per elasticity equation; H. Cross' iteration procedure. The sixth, and final, section deals with statically indeterminate structures: continuous beams and frameworks on rigid and elastic supports, bents, Vierendeel trusses, arches and chains reenforced by beams, continuous arches, deck framing with torsionally restrained beams.

K. Arnstein, USA

2879. Miklofsky, H. A., and Sotillo, O. J., Design of flexible steel arches by interaction diagrams, *Proc. Amer. Soc. civ. Engrs.* **83,** *(J. Struct. Div.),* ST 2, Pap. 1190, 36 pp., Mar. 1957.

Paper describes a direct method of structural design for all types of flexible steel arches by means of interaction diagrams. The interaction diagram developed gives the fiber stress and deflection of the arch cross section as a function of its dimensions. This diagram is analogous to a structural interaction diagram for a statically determinate structure, the beam column. The design method is illustrated by the design of the quarter point sections of the following steel arch bridges: the two-hinged Rainbow, the Bayonne, and the hingeless Rainbow.

From authors' summary by G. G. Meyerhof, Canada

2880. Turner, F. H., Analysis of bowstring arches, *Concr. constr. Engng.* **52,** 2, 61–72, Feb. 1957.

2881. Del Pozo, F., Cylindrical roof composed of a triangular mesh of metallic sections (in Spanish), *Inst. tech. Constr. Cem. Publ.* **8,** 176, 79 pp., 1956.

Starting with shell theory, author derives the equivalents of the elastic constants (moduli of elasticity, Poisson's ratios, and rigidity modulus) for use in a lattice-type thin shell structure. Procedures are developed for analyses based on (1) the shell membrane theory and (2) shells which can resist bending. For each of the two sets of equations developed, a numerical example is worked out in sufficient detail to be readily followed. Author claims initial experimental work so far confirms validity of theory.

R. B. B. Moorman, USA

2882. Bolton, A., The critical load of portal frames when sidesway is permitted, *J. Instn. Struct. Engrs.* **33,** 8, 229–238, Aug. 1955.

Paper demonstrates a method of obtaining the critical load of building frames in which sway can take place and includes approximations which are believed to be accurate and quick enough for use in such a design. From author's summary

2883. Allen, H. G., The estimation of the critical loads of certain frameworks, *Struct. Engr.* **35,** 4, 135–140, Apr. 1957.

It has long been known that the approach of elastic instability in a framework results in the amplification of bending actions due to transverse loads on the component members, to eccentricities, and to other imperfections which may be present. This amplification can cause premature yielding in extreme fibres and it may therefore affect adversely the load-carrying capacity of the structure. The moment-distribution method used in the analysis of these bending actions has been extended in the past to provide a means of estimating critical loads. In its usual form the method can be tedious, particularly in the region of the critical load, where convergence is slow. In a recent paper, the writer has developed a method which is direct in its approach and which enables the stiffnesses and hence the critical loads of plane braced structures to be evaluated with ease. For continuous beam and certain building frame problems the method has a parallel in the techniques adopted by Wood, when these are extended to deal with the effects of end-thrust. Such methods of estimation of critical loads are briefly reviewed, and it is demonstrated that they correspond to a convenient physical interpretation of the process of condensing a determinant. From author's summary

2884. Apostoleanu, P., Analysis of continuous beams considering settlement of supports (in Rumanian), *Indust. Const. Mater. Const.* **7,** 3, 149–163, Mar. 1956.

Continuous beams with two, three, and four spans are analyzed considering settlement at various supports. Method similar to that of three-moment equations (Clapeyron) is used, and equations with five unknown moments are introduced. Moment coefficients for continuous and partial uniform load are calculated for simplified calculations. Reference is made to publications by P. Prokofiev and C. V. Sahnovschi. J. J. Polivka, USA

2885. Chamberlin, S. J., Spacing of reinforcement in beams, *J. Amer. Concr. Inst.* **28,** 1, 113–134, July 1956.

The effect of spacing of parallel bars was studied in modified beams. Simulated variations in spacing were obtained by varying the width of the concrete at the steel in different specimens. Two-point symmetrical loading was used on one- and two-bar specimens made with two different concretes. Steel consisted of #4 bars—plain, old-style deformed, and modern deformed, and one modern #6 bar. Embedded length-diameter ratios varied from 6 to 21.33. Bar slippages at the load points and at the free ends, deflections, and steel strains were measured.

Ultimate loads increased with wider spacing until tensile failures developed. Measured bar slippages were greater for the narrowest spacing than for the others. All plain-bar beams failed by excessive slippage of the steel. Deformed-bar beams which did not fail in tension failed either by rupture of the concrete along a horizontal plane at the centerline of the steel or in combination with diagonal tension. Results indicate that an effective clear spacing of three bar diameters may be required.

From author's summary

2886. Asplund, S. O., Generalized elastic theory for pile groups, *Publ. int. Assn. Bridge struct. Engng.* **16,** 1-22, 1956.

The behavior of piles, under load, on elastic supports is investigated by imagining a rigid lever arm to be attached to the head of each pile, the arm extending to the elastic center, which is defined as the point where the application of a transverse force produces transverse displacement and no rotation and where a moment produces rotation and no displacement. Longitudinal, transverse, and rotational stiffness referred to this center are defined, and methods of measurement are indicated. A matrix method of analysis of pile groups is developed in a form suited to numerical computation. The method is extended to pile groups in three dimensions with lateral resistance.

L. M. Milne-Thomson, USA

2887. Varga, L., Method of pile allocation in case of equal pile load (in Hungarian), *Mélyépitéstudományi Szemle* **6,** 7/8, 356-357, July/Aug. 1956.

2888. Klock, M. B., and Sheridan, R. R., Study of shrinkage in concrete frames, *J. Amer. Concr. Inst.* **28,** 8, 791-796, Feb. 1957.

2889. Granholm, H., Stucco and light concrete (in Swedish), *Trans. Chalmers Univ. Technol.* no. 177, 45 pp., 1956.

2890. Rasmussen, B. H., Incremental collapse of ordinary reinforced concrete beams, *Publ. int. Assn. Bridge struct. Engng.* **16,** 439-456, 1956.

Tests are described which have been made with two-span beams in Denmark. Adaptation of bending moments at the support and below the (single) loads is shown as well as relation between curvature and bending moments. The latter follows Hooke's law until yield and, after this, remains constant.

Terminology in German summary is partly incorrect.

H. Craemer, Germany

2891. Barbaiani, M., Precast concrete members used for social cultural housing projects (in Rumanian), *Indust. constr. Mater. constr.* **7,** 8, 478-484, 1956.

Various types of pitched roof, floors, and ceilings assembled of precast and prefabricated members are described and illustrated and their advantages and costs discussed.

J. J. Polivka, USA

2892. Suler, S., and Sandru, A., Methods of reducing cost of concrete on construction by proper organization (in Rumanian), *Indust. constr. Mater. constr.* **7,** 2, 78-86, Feb. 1956.

Costs of concrete on construction site are analyzed, and suggestions made for their reduction, especially as to economy of delivery and transportation of materials (aggregates, cement), preparing concrete mixes on the site, transportation of ready-mixed concrete. Costs of materials, labor, use of necessary equipment, overhead, etc., for various qualities of concrete and application are calculated and presented in tables and diagrams. Practical example demonstrates how to use these data under various conditions. References are made to K. Eyman, T. Kluz, and to previous reports on theory and practice in concrete structures, published by state organization, M.C.I.C. and I.C., Bucharest, 1951.

J. J. Polivka, USA

2893. Christodoulides, S. L., The distribution of stresses around the end anchorages of prestressed concrete beams. Comparison of results photoelastically with strain gauge measurements and theoretical solutions, *Publ. int. Assn. Bridge struct. Engng.* **16,** 55-70, 1956.

Two- and three-dimensional photoelastic investigation was made to account for effects of cable ducts and inclination on anchorage stresses in posttensioned beams. Principal stresses were calculated from shear values and principal stress directions observed photoelastically by line integration of equilibrium equations starting from a point of known stress.

Three-dimensional photoelastic results compare favorably with those calculated from internal and external strains measured on full-scale concrete beam. Two-dimensional photoelastic results compare favorably with author's simplified mathematical solution [AMR **8,** Rev. 2303] of two-cable interference.

Theoretical solution of Guyon shows surprisingly good qualitative agreement with two-dimensional photoelastic results, but not with three-dimensional results.

Author's general paper on separation of stresses in photoelastic technique [AMR **9,** Rev. 3200] is of supporting interest.

G. L. Fisher, USA

2894. Halmagiu, M., and Scripca, L., Contributions to the study of a steel anchorage in prestressed concrete (in Rumanian), *Indust constr. Mater. constr.* **7,** 8, 450-469, 1956.

Results of laboratory tests with Korovkin anchorage system are presented, and this system is compared with other systems (Freyssinet, Magnel, Leonhardt-Baur); the advantages and disadvantages of all these systems are thoroughly discussed. Reference is made to publications by Cogny Marcel, Yves Guyon, St. Kaifasz, St. Kaufman, F. Leonhardt, P. Mlosch, V. V. Mihailov.

J. J. Polivka, USA

2895. Cholniky, T., Prestressed concrete pavement for airfields, *J. Amer. Concr. Inst.* **28,** 1, 59-84, July 1956.

Construction and testing of a 500 ft long and 12 ft wide experimental prestressed-concrete slab are described. Loads on the prestressing tendons, development of prestressing in the slab, its load-carrying capacity, and the effect of heat thereon were studied. The results proved the superior behavior of the slab in all respects, and indicated that such construction could be utilized in future airfield pavement construction. From author's summary

2896. Haas, A. M., Design and calculation of north-light shells in prestressed concrete for 2 × 131' continuous span (in Dutch), *Ingenieur* **68,** 15, 35-46, Apr. 1956.

Originally, span of 2 × 164' had been specified of which three preliminary designs are shown: two in shell construction and one of the windowless type (also in prestressed concrete).

For the span of 2 × 131' which has been chosen and which is now under construction, a simplified method of calculation developed by Mr. van der Eb was followed. The advantage of using prestressed concrete is explained, especially when curved cables are used. For this span the beam method of Prof. Lundgren led to the large deviations in the M_φ moments.

For a few characteristic cross sections, the values of the normal and shear stresses are shown.

As our knowledge of buckling of these shells is insufficient, tests were considered necessary. First investigations were made on small-scale card-board models; the expectation that elastic buckling was not liable to occur was confirmed.

Later on a model of prestressed mortar on a 1 : 10 scale was loaded in stages up to rupture. The factor of safety deduced for the actual structure was found to be more than 3½.

The north-light structure covers an area of about 225,000 sq ft. An underground service room has been provided for all ducts, pipelines, etc. The floor has been designed for 615 lbs/sq ft. It is of flat-slab-construction supported by columns on a 8' × 8' spacing. From author's summary

2897. Sundara Raja Iyengar, K. T., On a two-dimensional problem in the end-block design of posttensioned prestressed concrete beams, Proc. First Congress on Theoretical and Applied Mechanics Nov. 1-2, 1955, 107-112, Kharagpur, Indian Inst. of Technology.

Author deals with the plane stress problem in an infinite strip, the small edge loaded by arbitrarily distributed normal forces with axial resultant. Using Fourier development, he solves stress function as a sum of an infinite series of products of goniometrical and exponential functions on the one hand and a Fourier integral with an unknown function $A(\alpha)$ with α as parameter on the other. Boundary conditions yield a relation between the Fourier integral and the series coefficients, and, finally, an infinite equation system. Numerical evaluation restricting the first six terms gives coefficients (not stresses) for a simple case of loading. Reader should watch for misprints. W. Mudrak, Austria

2898. Steinhardt, O., and Möhler, K., Present status of the technology of wood construction. Part I, Influence of recent developments upon reediting of code regulations for structural computations (in German), *ZVDI* **98,** 34, 1869–1874, Dec. 1956.

Research and development in nailed, connectored, and glued wood construction resulted in information which should be given consideration in the design of built-up columns and beams. Existing regulations in German (1952), Austrian (1951), Swiss (1953), and Czech (1955) codes are discussed. The effectiveness of built-up components is considerably influenced by the cross-sectional design, that is, the arrangement as well as means of jointing of web and spacer members in columns and of flange and web members in beams. Comparative influencing factors are presented for a number of designs. E. G. Stern, USA

2899. Steinhardt, O., and Möhler, K., Present status of the technology of wood construction. Part II. Advanced methods of wood construction, *ZVDI* **98,** 35, 1919–1925, Dec. 1956.

The desirable trend of using wood members of small cross sections resulted in better methods of jointing such small members and in improved methods of construction. Generally speaking, engineered wood construction, as practiced with large timber structures, was applied to small structural elements and buildings.

In the field of nailed construction, experience was gained from nailed highway and railroad bridges of 164- and 98-ft span, respectively. During 10-year use of the latter bridge, 120,000 trains passed over it. During test loading with two locomotives, each of 175 metric-ton weight, the total deflection of the bridge amounted to 7/8 in. and the remaining deflection after unloading to less than 3/64 in.

Predrilling prior to nailing brought advantages to be given consideration. Use of double-shanked nails—with each shank driven into adjacent boards or planks—resulted in better load transmission and, hence, in greater permissible free spans.

Use of sheet-metal gusset plates along the lumber sides or inserted into precut grooves in the lumber allowed effective load transmission with closely spaced nails. Use of toothed gusset plates or connector plates between wood members resulted in large load transmission and in a rigidity of the joints which is comparable to that of glued joints.

Glued plate girders were improved by cutting the boards for the web members in such a way that the grain of adjacent web layers was at opposite angles of 5° to the horizontal axis of the girder.

Nailed trussed girders were built with the small-size diagonals spliced and nailed or glue-nailed to the flange members with carefully executed finger joints.

Steel-reinforced single and built-up beams as well as frames, catenary-steel-reinforced roof panels, and arches consisting of nonjointed rough-sawn laminations held together by friction resulting from tight and closely spaced cross-bolts are cited as examples of wood construction where steel played a vital part in transmitting principal forces. E. G. Stern, USA

2900. McGahan, A. F., Timber footbridges are cheap to maintain, strong, durable, *Municipal Engng.* July 1956.

Structural forms of timber footbridges and the span ranges which are economical for the various feasible designs are discussed. E. G. Stern, USA

2901. Laminated timber arches, *Timber Technol.* **64,** 2203, 252–254, May 1956.

English manufacture of laminated beams and their limitations are described in detail. E. G. Stern, USA

2902. Thornber, W., Glued laminated products, *Timber Technol.* **64,** 2204, 303–306, June 1956.

A comparison is made of American and English timber design and manufacturing practices. E. G. Stern, USA

2903. Niskanen, E., Glued laminated timber structures, Part I, *Aero. Res. Tech. Notes Bull.* no. 159, 1–4, Mar. 1956.

A good general description is given of advantages and limitations of glued laminated timber structures, with particular emphasis to USA laboratory and field experiences.

E. G. Stern, USA

2904. Niskanen, E., Glued laminated timber structures, Part II, *Aero. Res. Tech. Notes Bull.* no. 160, 1–8, Apr. 1956.

The effectiveness of gluing and scarf and butt joining of the laminations of glued timber structures is given detailed consideration, with particular reference to European and American experiences. Examples of laminated beams, arches including bowstring trusses, and frames are described.

A comprehensive bibliography of 22 important items covering this type of construction is presented.

E. G. Stern, USA

2905. Hemp, W. S., Stress analysis of multiweb boxes, Proc. Fifth International Conference, June 20–23, 1955, Los Angeles, Calif., 146–161; New York, Inst. of the aeronautical Sciences, Inc.

Analytical model of cantilever wing: flat constant chord covers in two-dimensional stress; pure-shear chordwise web-continuum without lateral interaction. Oblique coordinates are used with reciprocal system. Advantage is taken of both covariant and contravariant representations for cover stress and strain tensors, equilibrium conditions, Hooke's law, and energy expressions. Problem is solved for unswept case by familiar particular solutions of equilibrium conditions for shear-bending and torsion. Beamwise root boundary conditions are satisfied by virtual displacement-type energy analysis. Procedure is applied to unswept case, so heavy machinery is not demonstrated.

Results are rather according to expectation with some anomalies, seeing test-box aspect ratio was only one and one-half. Appearances indicate measurements were not made with rosettes back-to-back, particularly on 0.058-in webs where anomalies suggest buckling.

Many expressions are explicitly free of sweep angle because of coordinates. Hooke's law relations make up for this in work expressions and compatibility conditions. Author emphasizes an analog between straight and swept cases based on the "anisotropy" appearing in Hooke's law forms.

R. M. Davies, USA

2906. Noton, B. R., Honeycomb sandwich construction for supersonic aircraft, *Aircr. Engng.* **29,** 335, 13–18, Jan. 1957.

Sandwich construction with aluminum honeycomb cores bonded to faces with the adhesive films Redux 775, 775R, and Bloomingdale FM-47 is discussed. Drawings showing its applications to a series of components for various hypothetical aircraft are included. Sandwich materials for supersonic aircraft of the types now entering production are reviewed, as well as the application techniques of the new Redux films. Some rules gathered from experience for the design of components with honeycomb cores, and solutions of special design problems with hypothetical wing panels, are treated.

The paper then deals fairly fully with results from a program of FFA investigations on this type of structure. The specimens discussed were bonded with Redux 775 and FM-47 and consisted

partly of tensile tests on cores, compressive tests on sandwich columns, and shear tests on various sandwich webs. Design curves have been plotted in some cases. Further results are presented showing the influence of temperature on the shear strength of an aluminum alloy core and Redux 775 and FM-47 films. Also a few creep results are given where the object of the tests has been to determine the optimum curing temperature and time for applying Redux 775 to yield minimum creep values.

The room-temperature results illustrate the excellent properties of honeycomb structures and the elevated-temperature results indicate that bonded uninsulated aluminum sandwiches can be retained, even when the temperature due to kinetic heating approaches 70 C.

Finally, some remarks regarding future developments are made on various new "temperature-resistant" adhesives and on combinations of various materials for sandwich panels with external insulation, suitable for certain types of the next breed of supersonic aircraft. From author's summary

2907. Heal, M. G., Problems in estimating structure weights, *Aero. Engng. Rev.* **16,** 3, 52–56, Mar. 1957.

A presentation of some of the procedures that can help achieve greater accuracy in the estimation of structural weight.
From author's summary

Rheology (Plastic, Viscoplastic Flow)

(See also Revs. 2869, 2874, 2931)

2908. Drucker, D. C., The effect of shear on the plastic bending of beams, *J. appl. Mech.* **23,** 4, 509–514, Dec. 1956.

The end-loaded cantilever beam of perfectly plastic material has been studied in considerable detail, but many questions remain unanswered. As a first step in extension to plates, the concept is explored of an interaction curve relating limiting values of shearing force and bending moment for perfectly plastic beams. Simple illustrations demonstrate that, far more than in the elastic range, such interaction is not just a local matter but depends upon the geometry and loading of the entire beam. Useful interaction curves are obtained, nevertheless, with the aid of the upper and lower bound techniques of limit analysis, choosing the maximum-shearing-stress criterion of yielding for convenience. It is shown, in particular, that although a small amount of shear produces but a second-order reduction in the limit moment of beams, a small moment reduces the limiting shear value by a first-order term.
From author's summary by P. C. Dunne, England

2909. Davidov, I. V., Determination of displacements in compressed bent elements during their work beyond elastic limits (in Russian), *Proc. Kharkov Engineering-Design Institute* no. 4, 167–182, 1955; *Ref. Zh. Mekh.* 1956, Rev. no. 3094.

A method is suggested for determining the displacements of a rod system taking the longitudinal forces into consideration during its work beyond the elastic limits.

In order to determine the displacements, author uses More's known formula

$$\Delta a_p = \sum \int \frac{\overline{M} M_p ds}{EI} + \sum \int \frac{\overline{N} N_p ds}{EF}$$

into which he introduces the reduced moment M_r and the reduced longitudinal force N_r. Rectilinear rods of rectangular section of soft steel are examined. A hypothesis of flat sections is assumed. At first for displacements from bending (first term of More's formula) and then for displacements from axial elongation (second term of the formula) the relationships were determined between the moment and the longitudinal force at the limits of the elastic-plastic section of the rod in question. The presence of flow from one side of the section and the presence of flow from both sides is considered.

Equations are given for cases when the diagram of moments at the section is rectilinear and parabolic. The value of the longitudinal force within the limits of the section is considered constant. On the basis of the analysis, author comes to the conclusion that the influence of the longitudinal force in the first integral of More's formula should be taken into consideration, and the second integral can be neglected, just as in the elastic state.
Courtesy Referativnyi Zhurnal A. I. Strel'bitskaya, USSR
Translation, courtesy Ministry of Supply, England

2910. Ilyushin, A. A., Modern problems of the theory of plasticity (in Russian), *Journal of Moscow University* no. 45, 101–113, 1955; *Ref. Zh. Mekh.* 1956, Rev. no. 3081.

Survey report. Bibliography given of authors who worked or work in Moscow State University.
Courtesy Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

2911. Voce, E., A practical strain-hardening function, *Metallurgia, Manchr.* **51,** 307, 219–226, May 1955.

Article outlines progress in connection with the exponential strain-hardening function put forward in 1948, and discusses its advantages over the well-known power function of Ludwik. After considerable strain there is generally a change of régime, consistent with the change in the mechanism of deformation reported by Cook and Richards. The relationship between stress and indentation hardness is reviewed in the light of exponential function, and the nature of the fillet connecting the strain-hardening curve with the elastic line is indicated.
From author's summary

2912. Mott, N. F., Creep in metal crystals at very low temperatures, *Phil. Mag.* (8) **1,** 6, 568–572, June 1956.

A theory is given of creep in metallic single crystals at very low temperatures, which is based on the hypothesis that dislocations can pass through barriers, such as those provided by dislocations crossing the slip plane, owing to the quantum-mechanical tunnel effect. A detailed theory would depend on a knowledge of the atomic arrangements at the center of a dislocation, which in this case does not exist, but a rough calculation shows that creep should be independent of temperature below about 10 K in cadmium. From author's summary

2913. Briant, J., Study of the rheological properties of greases with the S.O.D. viscometer. Parts I, II, III (in French), *Rev. Inst. Fr. Petrole et Ann. Comb. liq.* **11,** 1, 113–133, Jan. 1956; **11,** 2, 247–287, Feb. 1956.

Author reviews literature on obtaining rate of shear and shear stress data from capillary and rotational viscometers. He describes use of Standard Oil Development (S.O.D.) viscometer for measurements on lubricating greases, with data fitted to three-parameter (σ, ψ, p) equation: $\eta = \sigma\eta_0 [1 + \psi/s\eta_0]^p$, where η is viscosity of grease, η_0 of oil from which grease is made, s rate of shear. I. M. Krieger, USA

2914. Kirk, J. M., Investigations of the rheologic properties of mastic asphalt, of the development of cracks in mastic asphalt roofs, and of the progressive opening of the cracks, *Acta Polyt.* no. 193, 16 pp., 1956.

The rheologic properties of mastic asphalt have been determined by experiments where the deflection curves of mastic asphalt bars have been measured. Furthermore, the variation of the rheologic properties with the variations of temperature has been established by these experiments. On the basis of the results found, an equation has been deduced which allows an approximate calculation of the tensile stresses arising in mastic asphalt when cooled.

An approximate calculation shows that the cracks will open progressively when the mastic asphalt is being exposed to variations of temperature and when, furthermore, the friction between the mastic asphalt and the foundation ranges within an interval, the limits of which are determined by the properties of the mastic asphalt and by the temperature. The progressive opening of the cracks will be furthered when there is a difference in the temperature of top and bottom of the mastic asphalt.

The results found have been confirmed by a number of experiments by which an alternating cooling and heating process made contractions develop in mastic asphalt bars.

From author's summary

2915. Weltmann, Ruth N., and Keller, T. A., Pressure losses of titania and magnesium slurries in pipes and pipeline transitions, *NACA TN* 3889, 22 pp., Jan. 1957.

Comparisons of experimental and calculated pressure losses are presented for Newtonian and non-Newtonian materials. The non-Newtonian materials were slurries of titanium dioxide particles suspended in water and of magnesium particles suspended in a hydrocarbon fluid. One of the slurries showed Bingham plastic flow behavior, while the other one behaved like a pseudoplastic material. The pressure-loss data were obtained for laminar, transitional, and turburlent flow through straight pipelines and pipe transitions of 1-inch and ¾-inch nominal pipe size. The pipeline transitions considered are 90° elbows; gate, ball, plug, and globe valves; contractions; and expansions. Transition loss coefficients, which are independent of the flow rate in the pipelines, even for laminar flow in the pipeline system, were determined for the transitions and are compared with those reported in the literature for Newtonian fluids.

The transition loss coefficients obtained for the Newtonian and non-Newtonian materials and those reported in the literature for Newtonian fluids agree within the errors of experiment. Thus these studies indicate that, for the design of pipeline systems, such as fuel systems, where the slurries have flow characteristics similar to those treated in this paper, the transition loss coefficients for Newtonian fluids can be used in the design calculations.

From authors' summary

2916. Dauber, C. A., Pipeline transportation of coal, *Combustion* **28,** 10, 39–43, Apr. 1957.

Failure, Mechanics of Solid State

(See Revs. 2866, 2883, 2924, 2927, 2938, 2940)

MATERIAL TEST TECHNIQUES

2917. Keller, W. M., The use of atomic energy in the testing of materials, *Mech. Engng., N. Y.* **79,** 3, 258–260, Mar. 1957.

2918. Close, W., and Muzzey, C. L., A device for measuring mechanical characteristics of tyres on the road, Instn. mech. Engrs. Auto. Div., Prepr., 17 pp. Nov. 1956.

Paper describes a machine which measures the mechanical force and moment characteristics of pneumatic tires moving over flat road surfaces.

Development of interest in tire force measurements is briefly reviewed, and the unique relationship of the Air Force-Cornell tire tester to other tire force-measuring equipment is indicated. The design evolution is discussed and the final configuration of mechanical, hydraulic, pneumatic, and electrical components is described in detail.

The axle carrying the test tire is supported at its ends by units which measure five forces. A sixth measurement, braking torque, is made simultaneously. These six measurements are used to compute total road reaction forces and moments, referred to any desired axes. The supporting mechanism permits the test tire to be steered 30 deg to either left or right, tilted (cambered) 30 deg from the vertical to left or right, and vertically loaded with a force variable from zero to 3,000 lb. A braking torque of 13,000 in.-lb can also be applied.

Electrical resistance strain gages sense the forces and produce time histories on a recording oscillograph. The entire equipment is mounted on a 2½-ton 6-wheel truck which can attain speeds up to 60 mph while testing tires.

From authors' summary

2919. Fonda, A. G., Tyre tests and interpretation of experimental data, Instn. mech. Engrs., Prepr., 19 pp. Nov. 1956.

The test techniques and associated equipment developed for use of the Air Force-Cornell Tire Tester have permitted road tests yielding unique data on the cornering characteristics of pneumatic tires. Account is given of tests performed for the Dunlop Tire and Rubber Corporation, involving variations of inflation pressure (18 to 45 lb per sq in.), camber (± 30 deg), and steer (± 30 deg); these angular ranges are unprecedented. The tires were nominally 5.00, 6.00, and 7.00 by 16 section, of normal construction but smooth and round to eliminate effects deriving from tread pattern.

The ensuing data analysis was based upon familiarity with aircraft derivative notation, the advantages of which are described, and upon simple tire theory, which is outlined in an appendix. The outstanding conclusions, from a practical standpoint, are (1) that camber thrust strongly affects the static stability of the typical automobile; (2) that the motor cycle operates with negligible slip angle below 30-deg tilt, whereas above 30-deg tilt appreciable slip angle must be developed; (3) that a plot of pneumatic trail against side force has great value because of its linearity and ready significance; and (4) that tire theory should be utilized to permit rational, concise interpretations of empirical data.

From author's summary

2920. Bazhenov, V. A., Perelygin, L. M., and Semenova, E. A., Testing of wood for compression across the fibres (in Russian), *Trudi in-ta lesa Akad. Nauk SSR* **9,** 315–331, 1953; *Ref. Zh. Mekh.* 1956, Rev. no. 3288.

A method and the results of compression tests across the fibers of the wood of pine, spruce, oak, ash, elm, birch, aspen, beech, and hornbeam are described.

During the tests, specimens of three forms were used: cubes having an edge of 30 mm, prisms of 20 × 20 × 30 mm (the latter dimension across the fibers according to the direction of the action of the force). Two series of specimens from pine wood were investigated (from the peripheral and central portion of the trunk) with the object of explaining to what extent the radius of the yearly layers influences the value of the limit of plastic flow.

Specimens were investigated at three degrees of moisture: 165–250, 10, 18–21%. The tests are performed on IM-4P machines of TSNIITHASH and GZIP.

The limit of plastic flow of the wood was determined with the aid of an autodiagram. In addition, the load corresponding to the limit of proportionality was found according to the compression diagram. Then, on the basis of these data, the values of the strength limit and the limit of proportionality were calculated.

The results of the tests showed that in the case of wood the conventional strength limits with tangential and radial compression differ and are in specific relationships proper to the given type of wood. The character of the change in the limit of plastic flow testifies to its independence of the value of the radius of curvature of the yearly layers.

Authors suggest using a prism of 20 × 20 × 30 mm (the latter dimension across the fibers) as a standard specimen for testing wood for radial and tangential compression.

It should be noted that a reliable connection between the volumetric weight of the wood and the limit of plastic flow is lacking both with tangential and with radial compression. The limit of plastic flow cannot be identified with the conventional limit of accuracy and it is inexpedient to identify it with the limit of proportionality, since in this case the physical essence of the phenomenon is lost: the development of deformation at a constant load. Resistance of the wood to compression across the fibers cannot be correctly characterized either by the volumetric weight of the wood or by its strength limit.

Courtesy Referativnyi Zhurnal

Translation, courtesy Ministry of Supply, England

2921. Marian, J. E., and Suchsland, O., Waviness of lumber and chipcore board, an investigation of the factors affecting surface stability, *Sven. Traforsklnst. Medd.* no. 70B, 12 pp., 1955.

Mechanical Properties of Specific Materials

(See also Revs. 2889, 2898, 2899, 2901, 2902, 2903, 2904, 2912, 2919, 2920, 3099)

Book—2922. Tiemann, H. D., Wood technology, 3rd ed., New York, Pitman Publishing Corp., 1951, xvii + 396 pp. $6.50.

Specific phases of wood technology, such as anatomy, identification, description and properties of species, physiological botany, mechanics, physics, chemistry, pathology, and processes, such as kiln drying, air seasoning, preservation, conversion, utilization, manufacture, distillation, pulping, and others, are presented in a comprehensive view of the entire field, which is one of the best merit of this excellent book. All these subjects, although to certain extent abridged, are treated with clear perspective and no significant feature pertaining to wood is omitted. Fundamental facts are described in readily comprehensible terms. Material has been amplified and added in this third edition, especially referring to plywood, sandwich construction, honeycomb laminates, and solid glue-laminated wood. New important discoveries, developments and improvements are included, especially in the field of kiln drying, humidity, examination of microscopic structure of wood by polarized light, permeability tests by means of soap bubbles, and others. Six appendices give practical information on various subjects and problems encountered in laboratory and specifications.

J. J. Polivka, USA

2923. Youngs, R. L., Effects of tensile preloading and water immersion on flexural properties of a polyester laminate, *U. S. Dept. Agric. For. Prod. Lab. Rep.*, 1856, 11 pp. + 1 table + 6 figs., June 1956.

This investigation was conducted to determine the effect of tensile preloading followed by water immersion on the flexural properties and water absorption of a typical polyester laminate. Specimens were cut from a parallel-laminated 181 Volan A polyester laminate and subjected to various tensile loads. They were then tested in flexure after being exposed, either while stressed or unstressed, to normal conditions or to various periods of water immersion.

Preloading and water immersion appeared to affect flexural properties independently. Preloading tended to lower the modulus of elasticity and modulus of rupture and to raise the proportional limit stress. Although preloading produced statistically noticeable effects on most flexural properties, the effect was so small as to be of little or no practical significance. Immersion in water for 30 days lowered the proportional limit stress and modulus of rupture, but did not significantly affect the modulus of elasticity. Preloading significantly increased the rate of water absorption by immersed specimens, but neither the additional moisture absorbed in 30 days by preloaded specimens nor the additional moisture absorbed by all specimens after 60 or 90 days appeared to have any significant effect on flexural properties.

From author's summary

2924. Collaud, A., Contribution to the study of ductility and toughness of gray cast iron (in German), *von Roll Mitteilungen* 13, 3/4, 25–74, July/Dec. 1954.

An interesting study with much data on mechanical properties of cast iron, but only the *form* of the functional relationships is given. Further, the imposition of a requirement of "good" castability makes the comments on metallurgical improvement of properties somewhat less than fundamental. The last comment is sound and well-recognized. Author's summary states (condensed): "... often assumed that working reliability of a gray iron casting depends on T. S. only. It is, however, only the complete stress-strain diagram which gives a full picture of (this) reliability. Gray cast iron is usually considered a brittle material due to low ductility, but tests of ductility are rarely made. Total deflection of an unmachined specimen is considered sufficient indication of the brittleness, but total deflection varies within only narrow limits, whatever the cooling rate and composition; thus no definite conclusions can be drawn. If test is made with machined specimen and total deflection is regarded as sum of the elastic and plastic deflections, the problem presents a different aspect."

"The ductility of cast iron is subject to quite different laws. At break-in load the plastic deflection depends directly on modulus of elasticity E_0 and increases when the notch deflection is decisively influenced by the ductility of the matrix and is inversely as the B.H.N.: f_p equals some function of E_0/BHN, where f_p is the plastic deflection, and since E_0 equals const. (stress/BHN), then f_p equals some other function of stress/(BHN)^2. This relation is generally valid, even if annealing, and shows how the ductility depends on plasticity of matrix. There is a definite dependency between the ductility and toughness; latter must be considered as product of T. S. and f_p at point of fracture. Apparently there is no relationship between either the total strain energy and T. S., E_0, or BHN. Different results are obtained if the total strain energy is divided into plastic and elastic. It is easy to prove that the elastic strain energy as well as the elastic deflection depends on BHN, i. e., the T. S. of the matrix. .... but plastic strain energy at point of fracture is proportional to T. S. and inversely as BHN. ..... comparing plastic strain energy at fracture with product of plastic deflection and T. S. .... find a complete parallelism which is not influenced by composition nor rate of cooling, expressed: T_p equals some function of (stress) (f_p), and since f_p is as shown above, then T_p equals some other function of (stress)^2/(BHN)^2. This formula shows clearly the extraordinary influence of matrix on ductility and toughness. .... It will not be possible to further improve metallurgically the properties of gray cast iron by increasing E_0 because the natural limit of 14,000 kg/mm^2 cannot be exceeded without sacrificing the good castability of gray cast iron. The metallurgy of gray cast iron must, therefore, aim at increasing the toughness, or .... try to get a ductility as high as possible for any value (given) of the T. S."

C. C. Osgood, USA

2925. Loria, E. A., High-temperature stainless, *Prod. Engng.* **28,** 4, 135–139, Apr. 1957.

2926. Grodner, A., Stainless steel for welded pressure vessels, *Welding J.* **36,** 4, 169s–176s, Apr. 1957.

2927. Shepheard, V., Structural steels for warship building with some notes on brittle fracture, *Trans. N. E. Cst. Instn. Engrs. Ship.* **73,** part 6, 301–330, 1956–57.

2928. Wilder, A. B., and Aebersold, A. F., Yesterday, today, and tomorrow—pipeline steels, ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56–A–97, 19 pp.

2929. Fairchild, F. P., Eight years of experience with austenitic-steel piping materials at elevated steam conditions, ASME Ann Meet., New York, N. Y., Nov. 1956. Pap. 56-A-181, 7 pp.

2930. Curran, R. M., and Rankin, A. W., Austenitic steels in high-temperature steam piping, ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56-A-217, 18 pp.

2931. Illg, W., and McEvily, A. J., Jr., Static strength of cross-grain 7075-T6 aluminum-alloy extruded bar containing fatigue cracks, *NACA TN* 3994, 25 pp., Apr. 1957.

Cross-grain specimens made of 7075-T6 aluminum-alloy extrusion were subjected to repeated axial loads until fatigue cracks of various lengths were formed. The specimens were then subjected to static tests to determine the residual static strength. Small cracks resulted in disproportionately large reductions of static strength. Comparison of these results with results previously obtained for loading in the with-grain direction revealed no significant difference. However, it is cautioned that cases may arise in which the cross-grain residual static strength of 7075-T6 or other materials is considerably inferior to the with-grain residual static strength, depending upon the relative shapes of the stress-strain curves. The effects of biaxiality and ductility on the notch sensitivity under static loading of sharply notched specimens are discussed in appendices. From authors' summary

2932. Chatterjee, G. P., Vibration damping capacity and anelasticity of metals and alloys from energy consideration, Proc. First Congress on Theoretical and Applied Mechanics, Nov. 1-2, 1955, 95-106, Kharagpur, Indian Inst. of Technology.

An historical account is given of the effect of plasticity, work hardening, and other factors affecting the damping capacity of materials which is defined as the amount of energy dissipated into heat per unit volume during one stress cycle. Damping capacities for several steels are tabulated, which are obtained from tests on torsion pendulums assuming viscous-type damping.

Using energy considerations, an expression is derived for the stress-strain relation for a so-called standard linear solid. For low stress levels it is assumed that the stress is proportional to the strain with component m, and energy loss per cycle proportional to the amplitude with component n. It is stated that $m = 1$ for elastic materials, $m = 0$ for plastic material, in which case n lies between 1 and 3 for all metals and alloys under different conditions of thermal and mechanical treatments. M. V. Barton, USA

2933. Probst, H. B., and McHenry, H. T., A study of the "toss factor" in the impact testing of cermets by the Izod pendulum test, *NACA TN* 3931, 13 pp., Feb. 1957.

The energies involved in the Izod pendulum impact test and the two components contributing to the total "toss energy" are considered. The components are recovery of stored elastic energy and kinetic energy contributed directly from the apparatus. A method to determine experimentally the kinetic energy imparted to the free half of a specimen by the apparatus is presented.

A low-capacity Izod pendulum test was used to determine the toss factor for three titanium-carbide-base cermets. With this apparatus, the toss factor was found to be less than 0.2 inch-pound. The validity of this small value was confirmed by high-speed motion pictures of the test. The study also shows that approximately 97% of the total toss energy of a broken cermet test bar is due to recovered stored elastic energy, which is a legitimate portion of the true rupture energy.

Alloys and cermets were tested at room temperature by the Izod pendulum and the results are compared with those obtained with the NACA drop test. It is shown that reliable impact data for brittle materials can be measured by using a low-capacity Izod pendulum. From authors' summary

2934. McSkimin, H. J., and Bond, W. L., Elastic moduli of diamond, *Phys. Rev. (2)* **105,** 1, 116-121, Jan. 1957.

The adiabatic elastic moduli of single crystal diamond have been determined by means of ultrasonic waves in the frequency range 20-200 Mc/sec. c_{12} is much lower and c_{44} much higher than respective values reported in the literature. In units of 10^{12} dynes per cm^2, the newly determined values are: $c_{11} = 10.76$; $c_{12} = 1.250$; $c_{44} = 5.758$. A critical analysis of uncertainties and a comparison with results obtained by others are made.

From authors' summary

Plasticity, Forming and Cutting

(See also Revs. 2931, 2934, 3085)

2935. Kunogi, M., A new method of cold extrusion, *J. sci. Res. Inst. Tokyo* **50,** 215-246, Dec. 1956.

A method of extrusion is described using a fixed punch and a fixed tapered die to produce shells. Experiments show that the geometry of punch and die influence the nominal extrusion pressure very considerably, and, with a suitable choice of the parameters, reductions in the extrusion pressure of 25 to 40% over conventional extrusion methods are obtained.

This reduction in pressure makes it possible to cold extrude low-carbon steel-alloy steels and austenitic stainless steels successfully. Results obtained using a wide range of alloys are quoted.

The success of cold extrusion of steels is dependent to a large extent on the qualities of the lubricant employed. Suitable lubricants were first tested by a friction test involving the compression of a hollow cylinder. The most promising lubricants were then used in the extrusion tests.

No theoretical analysis is made of the extrusion process employed, and the results obtained are entirely empirical.

F. Ellis, England

2936. Grant, H. R., Cold-forming methods for fabrication of inert rocket components during development, *Jet Propulsion* **26,** 12, 1088-1090, Dec. 1956.

A low cost, cold-forming process suitable for developmental operations is reviewed. Application of this technique to a precision ordnance rocket motor tube is described. The use of electric resistance welded low-carbon steel tube as a raw material is indicated as satisfactory. The application of a cold-formed, pressure tight, high strength joint is discussed, and a means of obtaining cold-worked ultimate tensile strengths considerably in excess of 150,000 psi is described.

From author's summary

2937. Siebel, E., and Panknin, W., Deep drawing process (in German), *Werkstattstech. Maschinenb.* **46,** 7, 321-326, July 1956.

Authors survey results of experimental and analytical investigations into deep drawing of cylindrical sheets. Discussion covers selection of blank size and drawing ratio, effects of sheet material and thickness, strain-hardening, surface preparation (coatings, lubricant carriers) and lubrication on drawability, pressing forces, and energy consumption.

Analysis is elementary, with emphasis on practical usability rather than formal exactitude, and the simplifications employed are at times drastic.

N. H. Polakowski, USA

2938. McCammon, R. D., and Rosenberg, H. M., The cold work introduced during the fatigue of copper, *Phil. Mag. (8)* **1,** 10, 964-966, Oct. 1956.

2939. Nakamura, K., and Nakamura, Y., Low temperature annealing of drawn wire *J. mech. Lab. Tokyo* **2,** 2, 25–28, 1956.

Paper presents results of a limited investigation conducted upon medium-alloy patented steel wires, such as might be used for suspension bridge cables, to determine effects of temperature rise during drawing and effects of various sequences of drawing and low-temperature annealing. Data indicate that tensile strength increases and ductility decreases with increase in temperature during drawing. Data also indicate that a final low-temperature annealing following drawing operations will increase tensile strength significantly; apparently this occurs whether or not the patented wire was fully annealed before drawing.

J. E. Goldberg, USA

2940. Takeyama, H., Murai, T., and Usui, E., Study on wear process of carbide tools, *J. mech. Lab. Tokyo* **2,** 2, 14–24, 1956.

Paper reports on experimental investigation of the characteristics of tool life when high-class cast iron FC27 and Ni-Cr-Mo steel SNCM 3 are dry-machined with G- and S- series carbides. Full test conditions are listed. Work clearly demonstrates that the relationship between flank wear and cutting time is better examined by a log-log plot. Both carbide series give two straight line wear stages, the critical wear being defined by the slope change. Numerous conclusions relating metal cutting variables are given.

P. Whitton, England

2941. Shaw, M. C., and Oxford, C. J., Jr., On the drilling of metals, Part 2, The torque and thrust in drilling, *Trans. ASME* **79,** 1, 139–148, Jan. 1957.

Report describes very careful work done at the Research Laboratories of the National Twist Drill & Tool Co. in cooperation with the Massachusetts Institute of Technology. Its experimental part covers drilling of holes 1/4 to 1-in. diam in SAE 3245 HT 196–207 Bhn with HSS standard helicoidal drills, 118° point angle, and no cutting fluid. According to discussion of M. Kronenberg, at the end of the paper, its "merit lies in the application of dimensional analysis to drilling operations. Although dimensional analysis has been applied with great success to turning operations as far back as 1939, it is the first time that this convenient method has been used for drilling research. The authors succeded in this way to prove the dimensional correctness of our (M. Kronenberg's and Prof. Boston's) earlier formulas."

Another merit of this work lies in stressing that the specific chip pressure psi (or, as the authors say, "the specific cutting energy") is an exponential function of chip load. Authors do not always justify their selection of exponent value, and their bibliography is rather incomplete and lists only a part of exclusively USA publications pertinant to the subject.

A. Niedzwiedzki, USA

2942. Rudorff, D. W., Principles and application of spark machining, Instn. mech. Engrs., Prepr., 12 pp., Feb. 1957.

The historical background of electro-erosion technique is briefly outlined and the difference between spark and arc discharges is defined. The underlying principle of the relaxation-type spark circuit as employed in industrial machines is explained, and development trends are discussed. The various factors bearing upon the efficiency of spark-erosion operations are enumerated. The mechanical features of a typical spark-erosion machine are described, and the range of machining operations for which spark cutting machines can be designed is outlined. Typical samples of work produced on a commercial unit are described and illustrated, and the properties of spark-machined surfaces are discussed.

From author's summary

2943. Wright, J. P., Ultrasonic deburring, *Amer. Machinist* **101,** 3, 129–136, Feb. 1957.

2944. Lynch, E. D., and Tooley, F. V., Effect of stress and temperature during forming on strength of glass, *J. Amer. ceram. Soc.* **40,** 4, 107–112, April 1957.

The effect of mechanical stress during the drawing process on the strength obtained was determined for large-diameter fibers of soda-lime-silica glass. Fibers were formed by down-drawing cane at a constant rate, using loads of from 100 to 8000 gm. Tensile strength was determined by transverse loading on annealed specimens. The results showed that the variation of temperature and load during forming increased the strength of the drawn fiber as much as 62%. The tendency toward increased strength persisted, but to a lesser extent, after the surface of the fibers was abraded.

From authors' summary

Hydraulics; Cavitation; Transport

(See also Revs. 2776, 2836, 3149, 3153)

Book—2945. Jaeger, C., Engineering fluid mechanics, London, Blackie & Son, Ltd., 1956, xviii + 529 pp. 60s.

This is an English edition of "Technische Hydraulik" 1949 [AMR **3,** Rev. 712] and "Hydraulique Technique" 1954, translated by P. O. Wolf, revised by the author; therefore it may be regarded as the third edition. Our readers will appreciate this edition as an excellent example of a European textbook. It contains the usual chapters with emphasis on unsteady flow (mass oscillations in surge systems, theory of water hammer, governing of turbines, propagation of waves). In the chapter on nonuniform flow, author presents his well-known generalized theorem of simultaneity of maximum discharge and minimum energy. Translation is perfect, technical editing and press work conform to high standards.

Reviewer would like to commend this book for one more reason; references are complete and exact, concise biographical data of authors are an important supplement for thorough readers. Certainly, these data need some improvement, as well as a few errors in the author index. History of the Chézy formula should be revised in accordance with a study by G. Mouret [*Ann. Ponts Chauss.* II, p. 165, 1921]. Some information on work done by Russians would make this modern treatise more complete.

S. Kolupaila, USA

2946. McGowan, J. C., Applications of the Eötvös equation to the study of parachors, *Recueil des Travaux Chimiques des Pays-Bas* **76,** 2, 147–154, Feb. 1957.

The Eötvös equation and the parachor equation of Sugden have been combined with the elimination of the surface tension term. The equation thus obtained has been used for the determination of certain parachors from density measurements.

From author's summary

2947. Hydraulic capacity of meandering channels in straight floodway, *Wuys. Exp. Sta. tech. Memo* 2-429, 15 pp. + 2 tables + 12 plates, Mar. 1956.

The investigation was conducted for the purpose of isolating the various factors affecting floodway capacities. Specific objectives were to determine the effects on floodway capacity of: (a) radius of curvature of bends; (b) sinuosity of channel; (c) depth of overbank flow; (d) ratio of overbank area to channel area; and (e) overbank roughness.

Typical channel and floodway conditions were reproduced in a 100- by 30-ft flume. Two floodway widths, three depths of overbank flow, and three degrees of roughness were used in testing channels of various degrees of sinuosity and various meander-belt widths.

It was concluded from the results of the investigation that:

(a) Where the floodway channel is relatively narrow (and small) compared to the floodway width, the effect of sinuosity of channel on floodway capacity is small.

(b) In the case of the 2-ft-wide channel and a 16-ft-wide floodway, the effects of increasing the channel sinuosity on floodway capacity becomes a critical factor.

(c) When the floodway width exceeds the meander-belt width by about 300%, the effect of channel sinuosity on floodway capacity becomes relatively small.

(d) Channel discharge is reduced about 8–10% by increasing the channel sinusoity from 1.20 to 1.40 and from 1.40 to 1.58.

From summary

2948. Polubarinova-Kochina, P. Ya., Slanted and horizontal wells of finite length (in Russian), *Prikl. Mat. Mekh.* **20,** 1, 95–108, Jan./Feb. 1956.

Systems of horizontal wells have large application in water power plants, whereas slanted wells are mostly used in naphtha mines. Author developed theories referring to various conditions in horizontal wells on the basis of thorough investigations in the Warsaw water plants with new filtration systems and on discussions with the director, V. Voynarovich, and his assistants, Vl. Skorashevski and V. Kolis, which were published in *Archives of applied Mechanics,* Warsaw, **7,** no. 3, 1955. Application of these theories to slanted wells under steady and variable pressure, built in different strata, is the subject of this paper. Bessel functions are used for the solution.

Reference is made to following authors who made similar investigations for vertical wells: F. Samsoe, N. K. Girinski, M. Masket, B. I. Segal. J. J. Polivka, USA

2949. Gerber, S., Theoretical and experimental study of the stability in a surge tank located downstream of a pressure gallery derived from a free-surface canal (in French), *Publ. sci. tech. Min. Air, France* no. 320, 122 pp., 1956.

Paper deals with stability of small level oscillations in a surge tank, preceded by a pressure gallery, which in turn is fed from a reservoir, through a free-surface canal; constant power regulation is admitted. Analytical study of the varied flow in the canal is conducted by means of operational calculus, according to a procedure by Cuenod and Gardel. For a canal of infinite length, a simple formula is reached which gives the report of the minimum area of surge tank necessary to obtain damped oscillations to the area given by Thoma's formula; for finite length, the development of calculations is indicated to determine the conditions of stability. It is recognized in particular, by means of numerical examples, that these conditions will vary, in consequence of successive wave reflections in the canal. The case of a restricted orifice surge tank is considered also. Some experiments, carried out in the hydraulics laboratory of Toulouse on a model of the Saint-Christaud power plant, give excellent confimation of the theoretical results; the experimental device is very interesting. D. Citrini, Italy

2950. Berman, K., and Carnavos, T. C., Some experiments with two-dimensional cavitating venturis, *Jet Propulsion* **27,** 2 (part 1), 148–150, Feb. 1957.

Investigations were conducted in three different ways: (1) Study of pressure distribution along the venturi; (2) high-speed photographic study of cavitation profile; (3) tests with fluid injected in several points of venturi. Ten models were used. Five of them had constant convergence semiangle of 45°, and divergence angles of 2 to 6 deg. The remainder had constant divergence angle of 4° and convergence angles of 15 to 90 deg. Eight to ten taps were provided to measure the pressure. Photographic apparatus was able to obtain 1000 frames/sec.

Pressure was studied by varying back pressure up to incipient cavitation. This was defined as the operating condition for which a further increase in back pressure would change the weight flow through the venturi. For different back pressures, it was possible to measure the length of cavitation zone, for divergent angles of 2 to 4°. Pressure recovery, i. e., back pressure as percentage of upstream pressure, was also determined for different convergence and divergence angles. Pressure drop was measured for incipient cavitating and for noncavitating conditions. It was reported that for divergent angles of 2 to 4° the difference for both conditions was small. Exploratory tests were conducted by injecting liquid from one section of venturi to another in closed loop system and also with liquid injected from an external source.

A. Balloffet, USA

2951. Numachi, F., and Sakai, H., Method of producing hydrofoil test-pieces for cavitation tests, *Sci. Rep. Res. Inst. Tohoku Univ. Japan* (*B*) **7,** 63, 189–201, 1956.

The test pieces of the hydrofoil for cavitation tests have been, not speaking of other institutes, mostly produced by hand work. Therefore, an improved method for their production has been devised with special reference to the following items: (1) Introducing machine work as much as possible, (2) devising effective and accurate method to make the gages of profile forms; (3) improving the method of calibrating the dimension.

From authors' summary

2952. Abe, S., On the mutual interference of two neighbouring cascades composed of hydrofoil or aerofoil profiles, *Sci. Rep. Res. Inst. Tohoku Univ. Japan* (*B*) **7,** 62, 1–14, 1956.

Author extends results of an earlier investigation on the interference produced by one row of airfoils upon another row following it. Potential flow solutions are obtained for airfoils (vortices were used in earlier work), and are said to be accurate for very close spacing and high values of interference. Six graphs are included, illustrating quantitatively the effects of variation of several parameters.

Since interference between the succeeding rows in axial flow compressors has been a subject largely neglected, this paper should be of timely interest. Worst limitations are that numerical results are computed only for flat-plate cascades, and the actual relative motion of the cascades with attendant inertial effects is neglected. Author indicates that method may be further extended to include these. R. A. Burton, USA

Incompressible Flow: Laminar; Viscous

(See also Revs. 2750, 2841, 2915, 2916, 2949, 2952, 2996, 2998, 2999, 3001, 3027, 3049, 3051, 3137, 3139, 3141)

Book—2953. Pai, S.-I., Viscous flow theory. Vol. II, Turbulent flow, New York, D. Van Nostrand Co., Inc., 1957, xi + 277 pp. $6.75.

Book covers the theoretical and experimental aspects of turbulent flow of incompressible and compressible flow. Equal space is given to mixing length and statistical theory. It fulfills a definite need for a convenient survey of turbulence on the graduate student level and will find widespread use. It should certainly be read by all who are interested in turbulent flow, for it contains a good deal of interesting material. Reviewer was particularly impressed by the chapter on turbulent diffusion.

However, there are some deficiencies which reviewer hopes will be remedied in future editions. Some are inherent in the present status of the theory of turbulent flow. The absence of a logical generally accepted theory of turbulent flow makes it difficult to write a clear well-organized text. In the present case, the attempt to cover such a wide field in less than 300 pages has led to many omissions and an excessive tendency to refer the reader to the literature. In reviewer's opinion, the most serious omission is the neglect of the attempts of Chou [AMR **1,** Rev. 127] and Rotta [AMR **5,** Revs. 329, 3503] to apply the statistical theory to practical problems such as boundary layer and pipe flow. A chapter covering this material would partially answer the frequent query as

to the use of all the elaborate machinery of the statistical theory. The other omissions are debatable individually, but the cumulative effect is evident.

The writing could stand improvement. The attempt to discuss the nature of averaging in the first chapter is commendable, but taken literally Eq. 1.3 makes the mean velocity independent of position! Another example, though a typographical error is partly responsible, is the first sentence of chap. 5, sec. 7.

In general, the book maintains a critical attitude towards the material, though there are lapses, as in chap. 6 on the compressible boundary layer where four analyses are presented without comparison or critical comment. W. Squire, USA

2954. Gibbings, J. C., and Dixon, J. R., Two-dimensional contracting duct flow, *Quart. J. Mech. appl. Math.* **10,** 1, 24–41, Feb. 1957.

Paper deals with the incompressible potential flow through two-dimensional contracting channels of finite length. These channel flows are obtained by first specifying flow patterns in the logarithmic hodograph plane. It is shown that certain of these patterns can result in infinite values, at points on the channel wall, of both the velocity gradient and wall curvature. A method of avoiding these undesirable features is given which alters the contraction boundary so as to replace them by wall portions along which the velocity gradient is constant. A numerical example is given.

From authors' summary by E. Leimanis, Canada

2955. Morduchow, M., On laminar flow through a channel or tube with injection: application of method of averages, *Quart. appl. Math.* **14,** 4, 361–368, Jan. 1957.

Paper presents an approximate closed-form solution for the flow through a channel and through a circular tube with porous walls. The solution is valid for the entire range of normal fluid injection velocities from zero to very large. The solution is obtained by first averaging over the cross section of the flow, the ordinary differential equation governing the flow. A series solution for the velocity distribution is assumed and the constants derived from the equations and the boundary conditions. The skin friction is determined. The solutions are compared with exact solutions at zero and infinite Reynolds number. A. M. Kuethe, USA

2956. Poggi, B., On the computation of air chambers for pressure lines (in Italian), *Ric. sci.* **26,** 12, 3681–3697, Dec. 1956.

The differential equations which govern the unsteady motion in pump discharge pipes with air chambers for instantaneous pump cutoff and within the validity of the nonelastic hypothesis are quoted.

The phenomenon is thus represented by a linear differential equation whose integration, extended by the author to the case of a polytropic transformation, although it implies the use of special transcendent functions, leads to simple relations determining the main design elements.

Conclusions of the paper concern the use of the formulas and their extension to the designing of air chambers with throttling orifices. From author's summary

2957. Vogel, R., Theoretical and experimental researches on ejectors (in German), *Maschinenb.-Tech.* **5,** 12, 619–637, Dec. 1956.

Paper treats ejectors in which both driving and induced fluids are incompressible. The over-all efficiency is determined from estimates of the component losses. The theoretical discussion is supported by a large number of experimental results which also include the effects of the shapes of the components. Special attention is paid to the effects of cavitation and to the problem of starting of ejectors.

Reviewer believes that paper will be of interest to everybody concerned with the design of ejectors for incompressible fluids.

N. H. Johannesen, England

2958. Maillet, E., Manach, J. L., and Costedoat, M., Aspects of centrifugal flow in a bent, slowly rotating channel (in French), *ONERA* no. 53, 43–49, Sept./Oct. 1956.

Flow through a transparent isolated single channel of an air compressor with radial vanes (600-mm diam, 385 rpm) has been studied by means of a stroboscope and fume filaments. Photographs show the whirl on the pressure side of the vane (at lower discharge) and the pulsations on the other side (at higher flow velocities). Peck has reported about analogous investigations with a centrifugal pump [AMR **5,** Rev. 1189].

O. Mastovsky, Czechoslovakia

2959. Levin, S. R., Mixing of flows in cruciform connections of pipe-lines (in Russian), *Trudi Leningr. tekhstil'n. in-ta* no. 5, 55–68, 1954; *Ref. Zh. Mekh.* 1956, Rev. no. 2834.

An approximate theoretical determination of the coefficients of local losses and the test data obtained by the author are given.

The theoretical investigation does not take into account the compression of the jet in the case of merging with subsequent expansion and formation of turbulence zones. Therefore the formulas obtained by the author cannot be fully reliable, which is confirmed by comparing them with the test data, which, particularly in the case of determination of coefficients of local resistances "to passage," give somewhat dispersed points.

The actual correction on the basis of the tests of the theoretical formulas, which was made by the author, is correct, probably, only within the limits of the test. I. M. Konovalov, USSR

Courtesy Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

2960. Chepinoga, M. M., The motion of a heavy viscous liquid in a rotating cylinder (in Russian), *Uch. zap. Rostovsk.-na-Donu-na* **32,** 4, 61–74, 1955; *Ref. Zh. Mekh.* 1956, Rev. no. 2875.

The plane-parallel motion of a viscous noncompressible liquid is examined, taking into account the force of gravity and limited on the outside by a rotating cylinder with a horizontal axis, and on the inside by a free surface. As a first approximation, a known solution is selected for circular motion disregarding the force of gravity; for additional components of the velocities and of the pressure, linearized equations and linearized boundary conditions on the free surface are used. The solution of the latter equations is given by cylindrical functions of the first order and by integrals from them; this solution is not taken to numerical results.

Courtesy Referativnyi Zhurnal N. A. Slezkin, USSR
Translation, courtesy Ministry of Supply, England

2961. Krzywoblocki, M. Z. V., Jets—Review of literature, *Jet Propulsion* **26,** 9, 760–778, Sept. 1956.

Review deals with the fundamentals and mathematical theory of free boundary flow and jets; with the distribution of velocity, density, pressure and temperature in laminar jets; transport of mass, momentum and energy in turbulent jets; and with closely related phenomena—the acoustical ones, designing of nozzles, orifices, wind tunnels with open jets, etc., being excluded.

From author's summary

2962. Vitman, L. A., Investigation of the density of irrigation by an atomized jet of liquid (in Russian), *Sb. nauch. rabot Leningr. s-kh. in-ta, Inzh. fak.* **11,** 101–113, 1955; *Ref. Zh. Mekh.* 1956, Rev. no. 2820.

Data are given of the experimental investigation of the distribution of a liquid in an atomized jet of a solution of glycerine of three concentrations at various distances from the mouth of a pneumatic atomizer for three atomizers at small air velocities.

The assessment of the distribution of the liquid in a jet was effected by collecting the liquid in measuring glasses placed at various distances from the mouth of the atomizers and at different radii with subsequent weighing on analytical scales. The atomizers were placed vertically with the opening downwards.

The density of the irrigation was calculated, i. e., the amount of liquid falling per unit of time per unit of surface, perpendicular to the axis of the jet.

An approximate formula of the relationship of the relative density of irrigation g_x/g_{ox} to the distance from the axis of the jet r was obtained in the form

$$\frac{g_x}{g_{ox}} = \exp. \left[-0.7 \left(\frac{r}{r_{ox}} \right)^{1.6} \right]$$

where g_x and g_{ox} are the density of irrigation at a given point of the section and on the axis of the jet, r_{ox} is the distance from the axis of the jet to the point of the section in which the density of irrigation is equal to 0.5. Graphs are given which show that this treatment makes it possible to generalize the data according to the densities of irrigation of the various liquids obtained for sections which are at varying distances from the mouth of the atomizer in different working conditions.

Author subdivides the process of atomizing the liquid by a pneumatic atomizer into the following three successive stages: breaking down the jet into drops with subsequent breaking down of large drops into smaller ones, acceleration of the drops as a result of interaction with the air current, and, later, transportation of the drops by the air current.

Author derives the relationship of the relative density of distribution of the liquid to criteria of similarity which determine the process of atomization and transfer of the liquid in the jet of air, taking as constant the coefficient of turbulent diffusion for various points of the jet, sufficiently removed from the nozzle.

Courtesy Referativnyi Zhurnal Ya. G. Shapiro, USSR
Translation, courtesy Ministry of Supply, England

2963. Bushmarin, O. N., A swirling jet in an accompanying flow of liquid of the same density (in Russian), *Trans. Leningrad Polytechnical Institute* no. 176, 115–136, 1955; *Ref. Zh. Mekh.* 1956, Rev. no. 2957.

On the analogy of the solution of the problem of a swirling submerged jet [see *Ref. Zh. Mekh.* 1954, Rev. no. 1664], an approximate solution is given of the problem of laminar and turbulent swirling jets. The jet is considered to be a three-dimensional boundary layer; the velocities and the pressure are represented in the form of series according to the negative degrees of removal from the source of the jet. The experimental investigation of the turbulent swirling jet in an accompanying flow showed satisfactory agreement with the calculated characteristics of the jet.

Courtesy Referativnyi Zhurnal G. L. Grodzovskii, USSR
Translation, courtesy Ministry of Supply, England

2964. Lighthill, M. J., Drift, *J. fluid Mech.* **1,** 1, 31–53, May 1956.

The changes in vorticity in the shear flow past a solid object are evaluated in terms of a function which describes the "drift" or distortion of material surfaces initially at right angles to the stream. The secondary velocities in the flow past an infinite cylinder, with the upstream velocity normal to its axis and increasing linearly with distance along the axis, are given simple expressions valid for small shears.

Darwin's results for the drift in the flow about a circular cylinder are used and extended to cover the example of flow about a sphere. The secondary vorticity in the shear flow about a sphere is calculated. The paper contains a number of useful concepts and results in the theory of secondary flows, and the analytical methods are useful for estimations near singularities and at infinity. W. R. Hawthorne, England

2965 Matthies, H. J., Resistance of stored crops to air-flow (in German), *VDI-Forschungsheft* **22,** 454, 40 pp., 1956.

Based on Reynolds' law of similarity, an effort was made to determine the hitherto unknown relations between the resistance of agricultural crops to air-flow and the independent variables effecting this resistance. Starting from earlier research work this effort resulted in obtaining a universal formula for the resistance of grain crops and of root crops. Additionally, a new formula was derived which is valid for grass crops and for foliage crops. The investigation on the influence of the dumping height and of the manner of dumping the crops is of special importance for practical applications. The present measurements confirm the result already found previously for packed beds of other materials that the resistance to air-flow in dumped crops varies almost inversely proportional to the fourth power of the porosity.

From author's summary

2966. Shuford, C. L., Jr., A theoretical and experimental study of planing surfaces including effects of cross section and planform, *NACA TN* 3939, 126 pp., Mar. 1957.

A summary is given of the background and present status of the pure-planing theory for rectangular flat plates and V-bottom surfaces. The equations reviewed are compared with experiment. In order to extend the range of available planing data, the principal planing characteristics for models having sharp chines have been obtained for a rectangular flat and two V-bottom surfaces having constant angles of dead rise of 20° and 40°. Planing data were also obtained for flat-plate surfaces with very slightly rounded chines for which decreased lift and drag coefficients are obtained.

A revision of the theory presented in *NACA TN* 3233 is presented for the rectangluar flat plate. The revised theory bases the aerodynamic suction effects on the total lift rather than solely on the linear component. Also a crossflow drag coefficient which is dependent on the shape of the chines was found from experiment to be constant for a given immersed cross section; however, for surfaces such as those having horizontal chine flare or vertical chine strips, the crossflow drag coefficient is constant only for the chine-immersed condition. The theory is extended to include triangular flat plates planing with base forward and V-shaped prismatic surfaces having a constant angle of dead rise, horizontal chine flare, or vertical chine strips. A method is also presented for estimating the center of pressure for surfaces having either rectangular or triangular planform. The results calculated by the proposed theory have been correlated only with the data considered to be pure planing; however, for conditions not considered pure planing, a method is given for estimating the effects of buoyancy. The agreement between the results calculated by the proposed theory and the experimental data is, in general, good for calculations of pure-planing lift and center-of-pressure location for flat plate, V-bottom, and related planing surfaces.

From author's summary

Compressible Flow, Gas Dynamics

(See also Revs. 2991, 2995, 2996, 2997, 3005, 3006, 3024, 3028, 3051, 3061, 3100, 3106, 3119)

2967. Lewis Laboratory Computing Staff, Tables of various Mach number functions for specific-heat ratios from 1.28 to 1.38, *NACA TN* 3981, 76 pp., Apr. 1957.

The tables of Mach number functions for a range of specific-heat ratios were compiled for use at the NACA Lewis Laboratory in solving fluid-flow problems. These tables provide information supplemental to the notes and tables presented in NACA Rep. 1135: Ames Research Staff, "Equations, tables, and charts for compressible flow" (1953). The program for computing the values given in the tables was prepared by members of the Lewis Laboratory computing staff for processing on automatic computing equipment at the NACA Langley Laboratory.

The tables were prepared originally for internal use by the Lewis Laboratory staff, and have proven to be effective for a wide

range of fluid-flow problems. Because interest has been expressed in obtaining copies of the tables for use by a number of visitors to the Lewis Laboratory, this report has been prepared in order to make the tables generally available.

From author's summary

2968. Spreemann, K. P., and Alford, W. J., Jr., Investigation of the effects of leading-edge chord-extensions and fences in combination with leading-edge flaps on the aerodynamic characteristics at Mach numbers from 0.40 to 0.93 of a 45° sweptback wing of aspect ratio 4, *NACA TN* 3845, 45 pp., Apr. 1957.

This investigation was made to determine the effects of 6° full-span and 3° partial-span leading-edge flaps in combination with chord-extensions or fences on the aerodynamic characteristics of a wing-fuselage configuration with a 45° sweptback wing of aspect ratio 4, taper ratio 0.3, and NACA 65A006 airfoil sections. The investigation was made in the Langley high-speed 7- by 10-ft tunnel over a Mach number range of 0.40 to 0.93 and an angle-of-attack range of about -2° to 24°. Lift, drag, and pitching-moment data were obtained for all configurations.

All the chord-extensions or fences in combination with the 6° full-span and 3° partial-span leading-edge flaps delayed the unstable pitching tendencies to much higher lift coefficients than those obtainable with the basic wing up to Mach numbers of 0.80 to 0.85. Beginning at a Mach number of about 0.80 to 0.85 the improvements in the pitching moments in the high lift range were considerably reduced for all the modifications investigated. The leading-edge flap configurations alone or the chord-extension alone (no leading-edge flap deflection) were less effective than the combination of the two devices in delaying the unstable pitching-moment tendencies to higher lift coefficients.

All modifications generally increased the maximum lift-drag ratios about 10 to 20% up to a Mach number of about 0.90. The minimum drag coefficients and the lift coefficients for maximum lift-drag ratios were increased by all the modifications; however, the 3° partial-span leading-edge-flap configurations gave about one-half the increases provided by the 6° full-span leading-edge-flap configurations.

From over-all considerations of stability and performance it appears that, with the model of this investigation, the 6° full-span leading-edge flaps in combination with the chord-extension over the outboard 35% of the span, with or without leading-edge camber, would be the most desirable configuration.

From authors' summary

2969. Crigler, J. L., Comparison of calculated and experimental load distributions on thin wings at high subsonic and sonic speeds, *NACA TN* 3941, 46 pp., Jan. 1957.

A method for calculating the aerodynamic loading on a wing in combination with a body is presented. The method is similar to that used by Falkner for wings in incompressible flow, except that the present method directly relates the downwash velocity to the lift on the wing in a compressible medium for any Mach number.

Calculated results are compared with experimental data for two wing-body configurations throughout a range of Mach number up to 1.0. Both wings were swept back 45° with an aspect ratio of 4. One of the wings had a taper ratio of 0.6 and NACA 65A006 airfoil sections and was tested with and without twist. The other wing had a taper ratio of 0.15 and NACA 64A206, $a = 0$ airfoil section at the fuselage boundary, fairing to an NACA 64A203, $a = 0.8$ (modified) airfoil section at the midspan. The sections of the wing from the midspan to the tip were NACA 64A203, $a = 0.8$ (modified).

The magnitude and the distribution of spanwise loading of the calculated data are in good agreement with experiment up to a Mach number of 0.95, and for the highly tapered wing the agreement of the calculated spanwise load distribution with the experimental distribution is still good up to a Mach number of 0.98.

L. Goland, USA

2970. Bryant, R. A. A., The one-dimensional and two-dimensional gas dynamics analogies, *Austral. J. appl. Sci.* **7,** 4, 296–313, Dec. 1956.

The analogy between inviscid high-speed gas flow and supercritical open-channel flow is shown to be applicable to one-dimensional transonic flow only for nonrectangular channels and to only one basic two-dimensional analogy; a rectangular channel must be used for the latter. An extension is also made in the two-dimensional analogy to unsteady rotational gas flows with weak shocks. It is finally concluded that in the study of gas flow over an airfoil the analogy utilizing a rectangular channel can only be valid if the gas flow is isentropic and subsonic.

H. G. Lew, USA

2971. Love, E. S., Base pressure at supersonic speeds on two-dimensional airfoils and on bodies of revolution with and without fins having turbulent boundary layers, *NACA TN* 3819, 65 pp., Jan. 1957.

An analysis has been made of available experimental data to show the effects of most of the variables that are more predominant in determining base pressure at supersonic speeds. The analysis covers base pressures for two-dimensional airfoils and for bodies of revolution with and without stabilizing fins and is restricted to turbulent boundary layers. The present status of available experimental information is summarized, as are the existing methods for predicting base pressure.

A simple semiempirical method is presented for estimating base pressure. For two-dimensional bases, this method stems from an analogy established between the base-pressure phenomena and the peak pressure rise associated with the separation of the boundary layer. An analysis made for axially symmetric flow indicates that the base pressure for bodies of revolution is subject to the same analogy. Based upon the methods presented, estimations are made of such effects as Mach number, angle of attack, boattailing, fineness ratio, and fins. These estimations give fair predictions of experimental results.

From author's summary

2972. Van Hise, V., Investigation of variation in base pressure over the Reynolds number range in which wake transition occurs for nonlifting bodies of revolution at Mach numbers from 1.62 to 2.62, *NACA TN* 3842, 41 pp., Jan. 1957.

An investigation has been made to determine Reynolds number and Mach number effects upon the base pressure of a nonlifting ogival body of revolution over the Reynolds number range in which wake transition occurs. The tests covered a Reynolds number range of approximately 20,000 to 10,000,000 and a Mach number range of 1.62 to 2.62. The results are compared with previous base-pressure data and also with the qualitative theoretical predictions of Crocco and Lees. Throughout the realm of wake transition the base pressure was found to vary with both Reynolds number and Mach number in the same qualitative manner as given by the theory of Crocco and Lees.

From author's summary

2973. Melnikov, A., The lift and wave drag of wings in a supersonic flow (in Russian), *Vestnik vozd. flota* no. 7, 50–63, 1955; *Ref. Zh. Mekh.* 1956, Rev. no. 1386.

A popular article, examining successively the following questions: A thin, transonic airfoil of arbitrary planform; the fundamental aerodynamic characteristics of wings of infinite span in a supersonic flow; the influence of wing tips; lift and inductive wave drag of a thin, rectangular airfoil of finite span in a transonic flow; lift and inductive wave drag of rectangular wings in a transonic flow; the influence of thickness and profile form of a wing in a transonic flow on its wave drag; frictional drag in a transonic flow.

L. A. Dorfman, USSR

Courtesy of Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

2974. Drougge, G., and Larson, P.-O., Pressure measurements and flow investigation on delta wings at supersonic speed, *Flygtekbn, Försöksanst, Medd.* **57,** 32 pp., 1956.

Pressure distribution measurements were carried out on two delta wings, one with a sharp and the other with a rounded leading edge. The sweep angle was 70 ° and the investigation was made at about Mach number 1.5 at different angles of attack. From the measurements, the lift distributions were evaluated and were compared with the linearized conical-flow theory. The agreement was quite satisfactory at small angles of attack, but with increasing lift the influence from leading edge separation became apparant. To explore this phenomenon more closely, a detailed investigation of the flow above the surface and in the boundary layer was performed. From authors' summary

2975. Perchonok, E., and Hearth, B. P., Effect of ambient-temperature variation on the matching requirements of inlet-engine combinations at supersonic speeds, *NACA TN* 3834, 16 pp., Jan. 1957.

Matching of supersonic inlet with compressor operating at constant mechanical speed is investigated for range of ambient temperatures. For flight speeds to Mach numbers 3.5, authors conclude that (1) ambient temperature variations are important for design; (2) variable-geometry intake should be sized for lowest likely ambient temperature at design speed. Normally, this gives increased spillage; and (3) with temperature variations likely, there is little possibility of satisfactorily matching fixed-geometry inlet with compressor over the design speed range.

F. G. Blight, Australia

2976. Rousso, M. D., and Baughman, L. E., Spreading characteristics of a jet expanding from choked nozzles at Mach 1.91, *NACA TN* 3836, 27 pp., Dec. 1956.

Authors are concerned with effects of jets on aircraft structures lying astern of the jet outlet. Their results add to the general knowledge of jets, and thus may potentially aid in the national design of gas-mixing devices for chemical processes, combustors, etc.

Work is an extension of previous studies of the spreading of high velocity jets into still air [*NACA RM* E9121, 1950; *NACA RM* E51F18, 1951; *NACA RM* E50E03a, 1950]. Hot jets from choked nozzles were expanded into parallel secondary streams moving at a speed of Mach 1.91. Temperature surveys of the jet were used to determine the extent of mixing at various distances downstream. The most important effect of the moving secondary stream is to reduce the size of the jet at a given axial distance, i.e. to reduce its rate of spreading. At this secondary velocity, jets are 55% smaller 8 nozzle diameters downstream of the outlet than they are in quiescent air. Some effects of internal and external nozzle geometry are also reported.

C. L. Coldren, USA

2977. Deich, M. E., and Stepanchuk, V. F., Calculation of maximum operating conditions of ejectors with an isobaric initial mixing zone (in Russian), *Teploenergetika* **3,** 3, 26–29, Mar. 1956.

Article deals with specific case of application of supersonic ejectors to condensers where initial mixing zone is isobaric. Functional relationship between suction pressure and coefficient of ejection at "limiting conditions" of the ejector is established, and a method for calculation of geometric parameters of the latter is given. Article is related to a previous work of Deutsch Koch and Stepanchuk published in title source in 1954, and is rather difficult to follow without reference to that work.

J. J. Dziewonski, England

2978. Mollo-Christensen, E., and Lewis, S. D., Measurement of pressure distribution on oscillating wings in supersonic flow, Part I. Experimental methods, Mass. Inst. Technol. Tech. Rep. 57-1, 45 pp., Dec. 1955.

A method for measurement of pressure on oscillating wings in supersonic flow has been developed and used with a moderate amount of success. A thin pressure-sensitive probe was traversed adjacent to but not in contact with an oscillating wing in a supersonic tunnel.

Pressures and wing displacement were recorded on magnetic tape during the run. The signals were analyzed by playing the tape back to a pen recorder through a wave-form analyzer and a phase meter. Data analysis was thus materially simplified.

Methods of wing excitation were developed. The results are given in a separate report.

From authors' summary

2979. Li, T.-Y., and Geiger, R. E., Stagnation point of a blunt body in hypersonic flow, *J. aero. Sci.* **24,** 1, 25–32, Jan. 1957.

Whereas Hayes ["Hypersonic flow fields at small density ratio" Ramo-Wooldridge Corp., May 1955] has treated the hypersonic flow about blunt bodies, present authors consider the stagnation point region in more detail. Specifically, the density in this region is assumed to be constant, and the ratio of free stream to local density is small but not negligible. The pressure coefficients near the stagnation point are calculated for blunt two-dimensional and axially symmetric bodies. These results agree with experiments and with Hayes' results within the limits of applicability of his theory. Shock detachment distances are also predicted, but with slightly less accuracy.

Equation 1a contains a typographical error.

L. H. Schindel, USA

2980. Bond, J. W., Jr., Structure of a shock front in argon, *Phys. Rev.* (2) **105,** 6, 1683–1694, Mar. 1957.

Steady one-dimensional shocks of such strength that one degree of ionization is of importance are considered. The equation of state of argon is computed, equilibrium conditions behind the shock front are evaluated, and a recombination coefficient is derived from detailed balancing. It is shown that, for a given shock velocity, the shock front is flat and nonluminous at first but soon becomes luminous with corresponding change in hydrodynamic variables and degree of ionization, and that the flat portion decreases in width with increasing shock velocity.

From the author's summary by A. J. Eggers, Jr., USA

2981. Drummond, W. E., Interaction of nonuniform shock waves, *J. appl. Phys.* **28,** 1, 76–85, Jan. 1957.

Weak nonuniform shocks (i.e., weak shock fronts followed by a rarefaction wave) in one-dimensional unsteady and two-dimensional unsteady flow are analyzed with respect to their interaction with each other or with a boundary between two media. Chandrasekhar's approximation (to neglect third-order terms in the shock strength) is used, so that shock polars may be approximated by characteristics in the hodograph plane and shock velocity can be written as the first three terms of a power series expansion in the shock strength (the coefficients in this expansion depending only on the entropy of the undisturbed fluid and on the equation of state).

Investigation concentrates explicitly only on boundary interaction, the generalization to interaction of two unequal nonuniform shocks being straight forward. Depending on the boundary conditions at the interface, there are two possibilities for the resulting flow when a prescribed nonuniform shock front strikes the boundary between two media: Part of the incident shock wave is transmitted into the other medium as a shock wave in both cases, but the accompanying effect is either that of a reflected shock wave or that of a reflected rarefaction wave, back into the first medium. Both possibilities are explicitly discussed both in unsteady one-dimensional and in steady two-dimensional flow (the case of Mach reflection, however, being excluded).

The reader may be referred to a recent paper by C. Heinz [*ZAMM* **37,** 63–73, 1957], where the unsteady problem for a solid wall is treated by a different method. H. Behrbohm, Sweden

2982. Srivastava, R. S., and Ballabh, R., Diffraction of oblique shock wave past a small bend, Proc. First Congress on Theoretical and Applied Mechanics, Nov. 1-2, 1955, 219-226, Kharagpur, Indian Inst. of Technology.

Authors purport to show in the diffraction of an oblique shock wave past a small corner that "after the shock configuration has past the corner the region between the incident and reflected shocks will not be disturbed for all possible shock strengths."

Reviewer believes this conclusion is self-evident since the strength of the incident shock is not a function of diffraction geometry. R. E. Duff, USA

Wave Motion in Fluids

(See Revs. 2783, 2787)

Turbulence, Boundary Layer, etc.

(See also Revs. 2953, 2963, 3001, 3033, 3062)

2983. Tatsumi, T., The theory of decay process of incompressible isotropic turbulence, *Proc. roy. Soc. Lond.* (*A*) **239,** 1216, 16-45, Feb. 1957.

Paper makes an important contribution to the mathematical study of the dynamics of isotropic turbulence. It describes calculations of the decay of the spectrum function using the first two of the usual set of dynamical equations, this pair of equations being made sufficient by the assumption of zero fourth-order cumulants of the velocity field. After extensive manipulation of the tensor relations, requiring considerable skill and determination, author obtains equations which allow the energy spectrum E to be determined as a function of wave number and time when the initial form of E and of the energy transfer function are given. Thus far, the paper covers effectively the same ground (independently) as that by Proudman & Reid [AMR **8,** Rev. 1442], although the details are different since the latter authors carried out their calculations mostly in terms of correlation functions.

The second half of the paper presents some calculations of the development of the spectrum function for various choices of the initial conditions. The case worked out in most detail is that in which the spectrum consists initially of a single line at some finite wave-number magnitude, and the rate of transfer across the spectrum is everywhere zero initially. The results make interesting reading for people working on turbulence, but are not easily summarized. G. K. Batchelor, England

2984. Campbell, G. S., Turbulence in the wake of a thin airfoil at low speeds, *NACA TM* 1427, 63 pp., Jan. 1957.

These wind-tunnel experiments were motivated by the need for basic input-function data in the problem of aircraft tail buffeting. Mean-square downwash was found to have nearly the same dependence on vertical position in the wake as that shown by total-head loss. For this particular wing, turbulent intensity, integrated across the wake, increased roughly as the 3/2 power of the drag coefficient. Power-spectrum measurements indicated a decrease in frequency as wing angle of attack was increased. The average frequency in the wake was proportional to the ratio of mean wake velocity to wake width. J. V. Becker, USA

2985. Brzozowski, W., Calculation of the characteristic quantities of the turbulent boundary layer on the basis of experimental research (in Polish), *Arch. Budoun. Naszyn* **3,** 2, 165-189, 1956.

Paper describes a method of calculating characteristic quantities of the boundary layer based on the author's experimental research. In reviewer's opinion, there is some risk in extending conclusions from the research of a single blade to such a qualitatively different phenomenon, such as the flow past a cascade, since the parameters determining the flow must have an influence on the boundary layer. The discrepancies between measurements (for instance, resistance and pressure) with various instruments should also be remembered. W. Fiszdon, Poland

2986. Skopets, M. B., An approximation method for calculating the turbulent boundary layer in the presence of heat exchange (in Russian), *Zh. tekh. Fiz.* **25,** 5, 864-876, 1955; *Ref. Zh. Mekh.* 1956, Rev. no. 2910.

An examination is made of the steady two-dimensional flow about a body of arbitrary form by a gas flow which moves at a low velocity in the presence of heat exchange, and an approximation method is proposed for calculating the resistance and heat exchange in a turbulent boundary layer at a Prandtl number of unity.

The suggested method of calculating the nonisothermal turbulent boundary layer is based on the use of the equations of momentum and energy written in Dorodnitsyn variables, and is essentially a generalisation of the known method of L. G. Loitsianskii [*Prik. Mat. Mekh.* **9,** 1945] for the presence of heat exchange.

Assuming that the profiles of velocities and temperatures in the boundary layer may be represented by uniparametric families of profiles, and permitting the analogy between certain regularities of the laminar and turbulent boundary layer, the author, using the individual results of his preceding work on the calculation of the laminar boundary layer in a noncompressible gas in the presence of heat exchange [title source, **23,** no. 1, 1953], solves the dynamic and heat problems separately. In order to solve the dynamic problem independently of the next problem, in the case of high temperatures and pressures, additional assumptions are made relating to certain heat functions, etc. A. A. Yarkho, USSR

Courtesy Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

2987. Hama, F. R., An efficient tripping device, *J. aero. Sci.* **24,** 3, 236-237 (Readers' Forum), Mar. 1957.

Author's recent investigations on transition from laminar to turbulent flow have revealed that the formation and development of a three-dimensional vortex loop are the essential features preceding the creation of a turbulent spot. As an application of this confirmation an efficient turbulence-stimulation or "tripping" device, which is commonly required for model tests in a wind tunnel as well as in a towing tank, is proposed. "Efficient" here means that the device should provide a consistent and fixed stimulation with the least parasitic drag caused by the device.

From author's summary

2988. Burkart, M. P., and Macovsky, M. S., Study of hydrodynamic parameters for design of a strut suitable for electromagnetic rodmeter, *David W. Taylor Mod. Basin Rep.* 1027, 19 pp., Mar. 1956.

Various modifications to a strut having an EPH section profile were investigated to determine their effectiveness in (1) stimulating boundary-layer transition without (2) appreciably lowering the speed of incipient cavitation. Those changes in shape which did not alter the speed of incipient cavitation were ineffectual, however, as transition stimulators. Further work was discontinued since a "herring bone" groove pattern developed by the Ordnance Research Laboratory was found to be effective as a transition stimulator without adversely affecting the onset of cavitation.

The vortex-excitation characteristics of struts were also investigated and the results were extrapolated to cover the full operating speed range of the rodmeter. This extrapolation showed the possibility of wake frequencies as high as 300 cps occurring at the maximum operating speed. Since the energy in the wake of a streamline shape is less than that of a blunt shape, it was concluded that the rodmeter should be streamlined as much as possible to minimize this source of undesirable vibration.

From authors' summary

2989. Winternitz, F. A. L., and Ramsay, W. J., Effects of inlet boundary layer on pressure recovery, energy conversion and losses in conical diffusers, *J. roy. aero. Soc.* **61,** 554, 116–124, Feb. 1957.

A study has been made of the effect of inlet conditions on the performance of conical diffusers with 4:1 area ratio and 5 and 10 degrees total angle of expansion. The conditions at entry were varied by using different approach lengths of diffuser inlet diameter, and by means of projecting annular screens of woven wire cloth. With this new technique it was possible to vary the velocity distribution substantially within moderate settling lengths, and to produce velocity profiles with inflections. Energy and pressure coefficients, as well as diffuser energy efficiency and the conversion efficiency, were found to depend on the diffuser angle β and the momentum-thickness ratio at inlet θ/D_0. The latter emerged as one of the chief parameters controlling diffuser performance. Variation in the inlet shape parameter H of the order of 20% did not significantly affect the pressure recovery or the losses in the diffuser. J. V. Becker, USA

2990. Hasimoto, H., Boundary-layer growth on a flat plate with suction or injection, *J. phys. Soc. Japan* **12,** 1, 68–72, Jan. 1957.

Author derives exact solutions of the Navier-Stokes equations for the time-dependent growth of the boundary layer on an infinite plate with uniform suction or injection. The unsteady motion of the plate starts at time $t = 0$ in a viscous incompressible fluid. The system of differential equations can be integrated for the following two special cases: (a) The tangential velocity of the plate is arbitrary and the normal velocity (suction or injection) is constant. (b) The tangential velocity varies with a power law of the time, where the normal velocity is proportional to $t^{-1/2}$.

The latter case gives similar velocity profiles. The results are compared with Rayleigh's solution for a flat plate moving suddenly in its own plane with constant velocity but without suction.
K. Pohlhausen, USA

2991. Yasuhara, M., Asymptotic behaviour of the laminar compressible boundary layer over a circular cylinder with uniform suction, *J. phys. Soc. Japan* **12,** 1, p. 102 (Notes), Jan. 1957.

The solution of the boundary-layer equations for the flow of a viscous incompressible fluid over a circular cylinder has already been given by W. Wüst and H. G. Lew. Author solves this problem for the compressible case, assuming that the viscosity depends linearly on the temperature. Numerical examples are given for several Mach and Prandtl numbers. K. Pohlhausen, USA

2992. Bruniak, R., Separation of boundary layer in compression waves (in German), *Öst. Ing.-Arch.* **10,** 2/3, 129–133, 1956.

Assuming that the velocity profile in a compressible laminar boundary layer is expressed exactly as in the case of incompressible laminar boundary layer, author discusses whether or not the separation of boundary layer occurs behind a compression wave. To do this, author calculates the velocity profile in the laminar boundary layer by applying Kármán-Pohlhausen's approximate method, and then use is made of Prandtl's method [Durand, "Aerodynamic theory," Vol. III (1935), p. 112] of estimating an adverse pressure gradient under which the retarded laminar flow in the boundary layer is still possible without separation.
S. Tomotika, Japan

2993. Gregory, N., Stuart, J. T., and Walker, W. S., On the stability of three-dimensional boundary layers with application to the flow due to a rotating disk, *Phil. Trans. roy. Soc. Lond. (A)* **248,** 943, 155–199, July 1955.

Experiments on the flow due to a rotating disk are performed (by Gregory and Walker) with observations made by the china-clay evaporation technique. Streaks are found on the surface, denoting a vertex system generated in a region of instability. The axes of the distrubance vortices take the form of equiangular spirals, bounded by radii of instability and transition. It is found that the radius vector of the spiral decreases in the direction of rotation, the angle between the spiral and the radius vector being 103°. About 30 vortices are observed around the disk.

Theory is developed (by Stuart) for the stability of three-dimensional boundary layers. It is shown that, within the range of certain approximations, the component of flow in the direction of propagation of the disturbance may be locally treated as a two-dimensional flow for stability purposes. (See Lin, Proc. 5th Symposium appl. Math. 1954, 1–18, for a similar conclusion and Dunn and Line, [AMR **9,** Rev. 819] for a corresponding conclusion for boundary layers in compressible fluids.) This neglects instability of the Taylor-Goertler type that might be induced by the curvature of the flow. It is shown that the velocity profile in the direction of the axis of the observed vortices has a point of inflection at zero speed, thus suggesting the occurrence of stationary vortices in this direction, as observed. (The china-clay technique can only reveal vortices stationary with respect to the disk.) However, calculations of the wave number of the motion give about 140 vortices around the disk, instead of 30. It is suggested that the effect of viscosity is responsible for the difference, but the analysis for the viscous case is not carried out.

Other experimental and theoretical investigations are made. For example, the measured velocity distribution in the laminar region is found in good agreement with theory, whereas that in the turbulent region is found to depart from the empirical formula commonly used. Comparison between the calculated flow pattern with the Goertler vortices is also made. C. C. Lin, USA

Aerodynamics of Flight; Wind Forces

(See also Revs. 2905, 2973, 2984, 3025, 3028, 3029, 3030, 3034)

Book—2994. Fiecke, D., Determination of the airplane-polar for design purposes, I. [Die Bestimmung der Flugzeugpolaren für Entwurfszwecke, Part I] (Forschungsberichte des Wirtschafts- und Verkehrsministeriums Nordrhein-Westfalen, no. 202), Köln und Opladen, Westdeutscher Verlag, 1956, 206 pp. DM 52.

This is the first book of a series sponsored by a German Ministry (see title), which, the reviewer believes, will be of great help to the aerodynamicist in preliminary design (when no wind-tunnel data are yet available) and to students of aerodynamics. This book, which is an excellent compilation of a vast amount of experimental data scattered around in the technical literature, will be followed by a set of worksheets and numerical examples.

In the incompressible flow domain, reviewer believes that the book compares favorably with the Data Sheets of the Royal Aeronautical Society, while presenting considerably more information. However, the compressible flow field is missing, although it is planned to be covered in the future.

The book contains 171 graphs, excellently presented and neatly printed. From these charts the designer can estimate with a high degree of accuracy the drag polar of a given airplane. The charts also facilitate the so-called "optimum configuration" calculations for a given mission.

The independent variables of the charts are: Reynolds number, profile data, boundary-layer characteristics, aspect ratio, sweepback, taper ratio, flap deflection, angle of attack or lift coefficient, ground effect, and a great variety of design data. Dependent variables are: minimum drag, drag due to lift, slope of lift curve, maximum lift, and zero lift angle.

Each graph gives references to the sources from which the data were taken. G. S. Gedeon, USA

Book—2995. Carafoli, E., High-speed aerodynamics (compressible flow), Bucharest, Editura Tehnica, 1956, 710 pp. + 2 graphs.

Translation (evidently by author) from Roumanian of "Aerodinamica Vitezelor Mari" [Editura Academiei R.P.R., Bucharest, 1956]. Scope is indicated by abbreviated chapter headings, followed by number of pages in parentheses; asterisk implies linearized or small disturbance theory: 1. Vector analysis (16); 2. Thermodynamics (24); 3. Equation of flow (20); 4. Propagation (12); 5. Forms of equations (11); 6. Steady flow through pipes and nozzles (11); 7. Plane shock waves (24); 8. Applications of one-dimensional flow (28); 9. Subsonic flow* (21); 10. Influence of compressibility upon wing of finite span* (33); 11. Subsonic two-dimensional flow, great variations in velocity (25); 12. Correspondence formulas, flow with circulation (18); 13. Transonic regime (25); 14. Two-dimensional supersonic flow* (19); 15. Body of revolution* (23); 16. Conical flow* (17); 17. Expansion of two-dimensional supersonic stream (27); 18. Supersonic profiles in second approximation (21); 19. Method of characteristics, two-dimensions (31); 20. Application of characteristics to plane effusors, diffusors and jets (20); 21. Circular cone (14); 22. Characteristics in axially symmetric flow, bodies of revolution and effusors (19); 23. Methods for supersonic wings of finite span* (16); 24. Conical flow* (21); 25 and 26. Angular wings of symmetrical thickness* (44); 27. Plane triangular wing* (23); 28. Thin plane wings of usual shape* (26); 29. Thin wings with variable angle of attack* (22); 30. Polygonal wings with flat plates normal to the wing* (27); 31. Conical flows of higher order* (30); 32. Unsteady flow* (24).

Despite great length (710 pp., 50 lines/p., 80 units/line), coverage must be regarded as incomplete in important respects; e.g., there are 193 pp. on conical wing theory but no mention of Evvard's method and only passing reference to slender wing/body theory; no reference to transonic work of Cole, Guderley, Vincente, or Yoshihara; no treatment of hypersonic flow. Treatment of unsteady flow closely approximates (albeit with reference) that of Temple ["Modern developments in fluid dynamics - high speed flow," Oxford Univ. Press, 1953, chap. IX]. Length, uneven coverage, mediocre English, absence of exercises, and—most importantly—absence of any index, renders book unsuitable as text. Practicians and research workers may find detailed treatment of particular problems valuable, but reviewer believes specialized monographs (such as in "Cambridge monographs on mechanics and applied mathematics") more efficient for this purpose.

J. W. Miles, USA

Book—2996. Robinson, A., and Laurmann, J. A., Wing theory, New York, Cambridge University Press, 1956, ix + 569 pp. $13.50.

Wing theory is of great practical importance and at the same time of considerable theoretical depth and interest. The history of the subject is roughly contemporary with the modern history of flight. Beginning with the pioneering work of Joukowski, Lanchester, Prandtl, and others, it has developed into one of the most important branches of the science of aeronautics, and is vital both for the prediction of the performance of an airplane and for its structural design.

The book under review presents a comprehensive summary of the classical theory of airfoils at low speeds in two and three dimensions, as well as some of the more recent developments in compressible flow. The treatment is at an advanced level and no one will contest the authors' statement that the reader requires a sound knowledge of the calculus and of the theory of functions of a complex variable. There is no escaping this level of mathematical treatment in a complete account of the subject. Reviewer received the impression, however, that the authors' concentration on the details of the analysis has sometimes obscured the simplicity of a result.

The book is divided into five large chapters. The first is on foundations, and presents basic concepts such as the equations of motion; source, doublet, and vortex distributions; boundary layer theory; the Joukowski condition; the wake, etc. Except for the first 15 pages, this discussion is all from the point of view of an incompressible fluid. The second is on steady two-dimensional, incompressible flow and presents various methods for the solution of the equations of potential flow around single airfoils, biplanes, and cascades, followed by a summary of Squire and Young's treatment of profile drag. The third is on steady three-dimensional, incompressible flow and presents various lifting-line and lifting-surface methods for straight and swept wings of finite span. This chapter also includes a section on wind-tunnel interference. The fourth is on steady compressible flow and presents various methods for the solution of the linearized equations of subsonic and supersonic flow around thin wings, together with some material on higher-order theories, and on transonic flow theory. The final chapter is on unsteady flow theory.

It should be emphasized that this book is concerned almost exclusively with an account of the mathematical aspects of the subject of wing theory. Little consideration is given to aspects of the subject for which quantitative theories are lacking and that must still be investigated by experimental means. The reader will thus have to go elsewhere to learn about the characteristics of wings at high angles of attack or at transonic speeds, or of the effects of scale, or of various auxiliary devices such as flaps, slots, etc.

It is evident that considerable delay has occurred in publication. The preface is dated 1953; the text proper appears to summarize the state of knowledge as it existed about 1950. As a result, the treatment of such topics as reversed flow and reciprocal relations, drag minimization for supersonic speeds, low-aspect-ratio wing theory, transonic theory, hypersonic theory, etc., that have been developed in the last decade would require amplification in a correspondingly comprehensive summary of the present state of knowledge.

All in all, however, the book is a very good one and the authors are to be congratulated in producing such an authoritative work. It is, by far, the most complete account of the various potential theories for wings yet published and is a valuable addition to the literature of aerodynamics.

J. R. Spreiter, USA

2997. Bobbitt, P. J., and Maxie, P. J., Jr., Sidewash in the vicinity of lifting swept wings at supersonic speeds, *NACA TN* 3938, 49 pp., Feb. 1957.

In order to calculate the induced loading on a store, missile, or pylon situated in close proximity to a wing-fuselage combination, a detailed knowledge of the flow field is required. Present paper provides some of this needed information by presenting equations and charts that enable the determination of sidewash in the vicinity of semiinfinite triangular wings at small angles of attack. These results may also be used directly in sidewash determinations for the conical part of the flow exterior to wings having finite spans and chords. At points in the flow field affected by the finite-wing wake or tip, additional considerations are necessary to determine the sidewash. Both the subsonic-wing and supersonic-wing leading-edge conditions have been treated; hence, sidewash is obtainable for all supersonic Mach numbers and leading-edge sweep angles for sweptback wings.

From authors' summary by R. Gullstrand, Sweden

2998. Licher, R. M., Increase in lift for two- and three-dimensional wings near the ground, *Douglas Aircr. Co. Rep.* SM-22615, 45 pp., Oct. 1956.

Method used is to represent chordwise as well as spanwise vorticity distribution by a number of bound and free vortices, Wieghardt's system. Exact results (Timotika) by using conformal mapping allow studying the accuracy of approximation of using a number of vortices instead of continuous distributions for two-dimensional flat plate and cambered airfoils. For the three-dimensional wing, several simple networks of bound and trailing vortices are examined; results are compared with Tani's theory. The number of vortices necessary depends on ratio of wing height above ground to wing chord.

Ground effect on lift only is discussed. Five diagrams for airfoils and 8 for rectangular wing are given. Author mentions the importance of effects for the flapped case and the influence of wing thickness. These as well as the ground effect on moment are not considered here.

Advantage of the present paper is the simple and clear mathematical method used and the diagrams given. No comparison is made between the theoretical results of the paper and experiments. F. Keune, Germany

2999. Sidorov, O. P., Flow about a very simple annular wing (in Russian), *Trudi Kazansk. aviats. in-ta* **29**, 9–24, 1955; *Ref. Zh. Mekh.* 1956, Rev. no. 2737.

The problem is examined of flow about a body by an ideal uncompressed fluid which is formed when the potential of a uniform parallel flow is added to the potentials of the ring of the sources and of the ring of the sinks disposed in planes perpendicular to the direction of the parallel flow.

A method and the results obtained of calculation of the pressure distribution in the section of the annular wing are given, and it is shown that the annular wing of finite thickness is subjected to multilateral compression during axial symmetrical flow by an incompressible fluid, i.e., in each of its meridional sections lift occurs which is directed towards the axis of the ring.

An expression is given (by means of special functions) for the flow function of a very simple annular wing, and a method of plotting its contour is described. Yu. A. Rizhov, USSR

Courtesy Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

3000. Murai, H., Theory of flow through cascades of arbitrary airfoil shape with large camber and thickness ratios, *Sci. Rep. Res. Inst. Tohoku Univ. Japan (B)* **7**, 16–29, 1956.

Paper is expansion of AMR **9**, Rev. 2971. It presents hodograph method of solution for incompressible, inviscid cacsade flow. Numerical methods must be used for solution of airfoil of arbitrary shape. Two examples are presented; one for comparison with tests of Numachi and Kurakawa, the other for tests of Hausenblas.

For measured pressure distribution around the airfoil, the theoretical values check very closely.

W. D. Baines, Canada

3001. Temple, G., The dominant derivative method in aerodynamics, Proceedings, Eighth international Congress on theoretical and applied Mechanics, Aug. 20–28, 1952, Istanbul, Turkey, Vol. II, Part IV-General lectures and sectional addresses, 85–88. Istanbul, Faculty of Science of the Univ. of Istanbul, 1955.

This iterative method is applicable to problems in which velocity derivatives in the main stream direction are small compared to those in transverse directions. In the first approximation, longitudinal derivatives are neglected altogether; in higher approximations, they are introduced as correction terms. The relation of the method to Munk airship theory and its application to the Blasius flat plate boundary-layer problem are discussed.

M. Holt, USA

3002. Lowry, J. G., and Polhamus, E. C., A method for predicting lift increments due to flap deflection at low angles of attack in incompressible flow, *NACA TN* 3911, 29 pp., Jan. 1957.

Method presented differs from other current methods in its ease of application and more general utility. It is applicable to swept wings of any aspect or taper ratio. Also included is a simplified method for estimating the lift curve slope throughout the subsonic speed range. H. Lomax, USA

3003. Simmons, J. C., and Dunsby, J. A., The estimation of the lift due to full and part span controls, *J. roy. aero. Soc.* **60**, 548, 545–549 (Tech. Notes), Aug. 1956.

3004. Santangelo, G., Influence of deviation of jet upon some fundamental performances of jet-propelled aircraft (in Italian), *Aerotecnica* **36**, 6, 395–401, Dec. 1956.

Article deals with vehicles propelled by turbojet engines and studies the effect of deviations of the jet on the aircraft regarded as a particle. Following cases are treated: rectilinear level flight; take-off; landing; curvilinear flight in a horizontal plane. Analytical methods are developed illustrating the effect of the ratio of thrust component normal to velocity/weight on the flight performance. It is stressed that the importance of these effects decreases as the altitude increases. A. Miele, USA

3005. Englert, G. W., and Luidens, R. W., Wind-tunnel technique for simultaneous simulation of external flow field about nacelle inlet and exit airstreams at supersonic speeds, *NACA TN* 3881, 25 pp., Jan. 1957.

An investigation was made of several ways of simultaneously simulating an external pressure field generated by an engine exhaust jet and an air inlet. The techniques investigated used high-pressure air piped upstream through a simulated jet to the exhaust nozzle of the engine. It was then discharged through perforations in the pipe or in a downstream direction through a target-type reverser at the end of the pipe. This air combined with the engine-inlet air to form a jet contour. The measured results indicated that the pressure field in the vicinity of the exit station and external to a real jet could be adequately simulated while keeping the inlet at critical or supercritical mass flow.

From authors' summary by J. R. Spreiter, USA

3006. Powell, J. B. L., The effect of dihedral on the aerodynamic derivatives with respect to sideslip for airfoils in supersonic flow, *Quart. J. Mech. appl. Math.* **9**, 4, 425–440, Dec. 1956.

Paper extends previous work [AMR **9**, Rev. 3007] on the effect of dihedral upon lift and drag coefficients for thin wings whose planform is symmetrical about center chord. In present work the aerodynamic derivatives with respect to sideslip are determined within linearized framework. Problem is divided into two parts, depending on whether the wing leading edges are subsonic or supersonic. Solutions for the surface pressure distribution are obtained utilizing conical field theory and conformal mapping techniques.

Numerical results for the force derivatives on a delta wing are presented in graphical form. For a delta wing with a dihedral angle α less than 50° rolling derivative is found to vary approximately as $\sin \alpha$, while the yawing and sideslip derivatives vary approximately as $\sin^2 \alpha$. Greatest deviation from this approximation occurs when leading edge is swept at angles lying inside and close to Mach cone surface. R. F. Probstein, USA

3007. Petrie, D. M., Dynamic stability control increases aircraft range, *Control Engng.* **4**, 4, 94–98, Apr. 1957.

Paper points out that appropriately designed autopilot tends to maximize L/D ratio and thus the range of aircraft, provided aircraft is approximately neutrally stable at cruising speeds. Further, pitch maneuver magnitudes are not as restricted by elevator effectiveness. Design of such an autopilot must take into account various nonlinear effects and will be costly.

The important reliability and safety questions are only mentioned. L. Becker, USA

3008. Stone, R. W., Jr., Interpretation of wind-tunnel data in terms of dynamic behaviour of aircraft at high angles of attack, *AGARD Publications* AG18/P8, 24–50, June 1955.

Recent basic changes in airplane configuration, primarily the trend to swept and low-aspect-ratio wings and the concentration of mass in the fuselage, have caused the general characteristics of airplanes to change such that dangers of large and possibly violent motions triggered by causes other than the stall itself are now possible. Of major importance are the pitchup, directional

divergence, the effects caused by inertia coupling during combined lateral-longitudinal motions, and reductions in roll damping and dihedral effectiveness at angles of attack below the stall. Wind-tunnel measurements may be used to recognize the existence of most of these problems, and in general there appear to be ways of improving such deficiencies. The problem existing in the combined maneuvers cannot be recognized directly from wind-tunnel measurements and will require some rather extensive calculations to evaluate any given design. From author's summary

3009. Billion, E., An investigation of some longitudinal stability and control troubles at high subsonic speeds, *AGARD Publications* AG18/P8, 13–23, June 1955.

Static measurements in a wind tunnel, reduced according to classical theory of linearized small deviations, are already able to explain some longitudinal handling troubles which are of prime interest in operation.

A line of thought has yet to be established to know what degree of refinement has to be reached in the process of reduction and to estimate the improvements to be expected from properly dynamic measurements such as the measurement of damping in pitch.
From author's summary

3010. Stever, H. G., Van Meter, J. T., Larrabee, E. E., Bicknell, J., and Parsons, T. R., Modern trends in dynamic stability analysis and experiment, *AGARD Publications* AG18/P8, 1–12, June 1955.

Book—3011. Cescotti, R., Glossary of aeronautical definitions, English-German/German-English, Vol. 4 [Luftfahrt-definitionen, Englisch-Deutsch/Deutsch-Englisch, Band 4], München, Hanns Reich Verlag, 1956, 270 pp.

"Glossary of aeronautical definitions" is a systematic compilation of definitions which have been formulated either by the International Civil Aviation Organization (ICAO) or the British Standards Institution during the post-World War II years. The British Standards Institution definitions have been selected by the Advisory Group for Aeronautical Research and Development (AGARD) to form the basis for an interlingual aeronautical dictionary. This glossary has over 3500 basic aeronautical definitions and definition cross references. From preface

3012. Pritchard, J. L., The dawn of aerodynamics, *J. roy. aero. Soc.* **61,** 555, 149–180, Mar. 1957.

3013. Czernin, A., Power loss and fuel pressure rise due to centrifugal pumping in tip-driven helicopter rotors, *J. roy. aero. Soc.* **60,** 548, 553–555 (Tech. Notes), Aug. 1956.

Aeroelasticity (Flutter, Divergence, etc.)

(See Revs. 2785, 2978, 2984)

Propellers, Fans, Turbines, Pumps, etc.

(See also Revs. 2786, 2952, 2956, 3013, 3050, 3065, 3117, 3118)

3014. Stier, R., Comparison for the design of steering data of slot-controlled two-stroke engines, *Motortech. Z.* **18,** 1, 8–10, Jan. 1957.

A comparison method is given for the design of steering slits for the two-stroke cycle engine. The method of calculation is straight forward and relatively simple. Designs may now be analyzed at least to the extent of establishing limiting boundaries without the expense of production models. This analytical method should prove very useful in steering duct and exhaust duct design.
J. H. Davidson, USA

3015. Zwicky, E. E., Jr., The use of digital computers in the mechanical design of large steam turbines, ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56-A-139, 7 pp.

3016. Wiebe, W. H., Design of warped buckets for optimum efficiency, ASME Spring Meet., Birmingham, Ala., Apr. 1957. Pap. 57-S-1, 7 pp.

Paper deals with steam flow and design criteria of axial turbine stages with warped buckets. Two principles of design and methods of calculation are discussed; i.e., for balanced or equilibrium flow and for optimum diagram efficiency. For the first method an empirical relation is introduced which enables the differential equation for balanced flow to be integrated over the whole blade length with sufficient accuracy. In the second part the differential equation for optimum efficiency is solved for the determination of the reaction, which in turn permits the design of velocity diagrams for any blade sections. For all these derivations, suitable dimensionless variables are introduced and applied.
From author's summary

3017. Ash, J. E., Measurements of relative flow distributions in mixed-flow impellers, ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56-A-205, 8 pp. + 1 table + 13 figs.

Results of experimental investigations of the relative flow in the rotating passages of a mixed-flow impeller are presented. Comparisons of the measured results are made with theoretically predicted results for the purpose of evaluation of an impeller-design method and also for the evaluation of a more exact quasi-three-dimensional blade-to-blade numerical solution of the flow. Axial symmetry was assumed for the blade design and the fluid was considered to be nonviscous and incompressible. The blades were designed as bound-vortex sheets having a zero ring component of vorticity at the design point. The blade-to-blade solution was computed on the surface of revolution generated by the mean meridional streamline. From author's summary

3018. Caric, G., Hydroelectric power with reservoir at Jablanica—first concrete arch dam on Neretva River (in Serbian), *Naše Gradevinarstvo* **11,** 1, 2–14, 1957.

Paper is a detailed description of the plant designed under the direction of Jaroslav Černi. Arch dam, 250 ft high, was selected after study of two other alternate designs (gravity dams in concrete and stone). The dam has some characteristics of a typical constant-angle dam, system Jorgensen, and also carries a highway bridge in reinforced concrete. Water from the lake, about 6 mi. long, is conveyed by two parallel pressure tunnels to the surge tower and from there to the underground hall with 6 Francis turbines (31,000 hp per unit), generators, and transformers. Total discharge is 230 cps. Concrete dam was poured in 14 blocks with vertical joints. 70% Portland cement was mixed with 30% slag cement, altogether 430 lb/cy aggregates, maximum size 3 in. According to tests made in Zagreb, Milan, and Zurich, water-cement ratio 0.56 was used. Tunnels, from 14 to 20-ft diam, were built in concrete (maximum wall thickness 32 in.), partly in reinforced concrete (14-in. wall thickness, with 2 ¾-in. Torkret waterproofing).
J. J. Polivka, USA

3019. Saito, S., Experimental investigation of runaway speed of Kaplan turbine (Rep. 1), *Sci. Rep. Res. Inst. Toboku Univ. Japan (B)* **7,** 45–65, 1956.

In an earlier paper, a method of theoretical calculation of runaway speed of a Kaplan turbine had been obtained, while in the present paper the experiments on a Kaplan runner are performed, and good agreement between the theory and the experiment are confirmed. Moreover, by taking into account the fact that mechanical loss of the machine comes into question in obtaining a runaway speed of a prototype from its model experiments, the aspects of change of runaway speed during model experiment due to mechanical loss are first clarified by the present experiments,

and then the method of obtaining a runaway speed of the prototype is suggested in accordance with these model experiments. Further, by investigating the effect of cavitation growth on runaway speed, it is shown how to treat the effect of cavitation on runaway speed in the case where that speed will be found theoretically or experimentally.

From author's summary by P. Franke, Germany

3020. Gregory, A. T., and King, J. A., The evolution of a small turbojet, ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56-A-203, 7 pp. + 20 figs.

3021. Heath, F. R., Designing jet engines with a medium-size digital computer, ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56-A-143, 7 pp.

3022. Citrini, D., A contribution to jet-pump design (in French), *Houille blanches* **11,** 6, 837-842, Dec. 1956.

Operation of jet pumps handling two fluids of equal specific gravity and not subject to changes of state is described. Corrections to certain apparently erroneous hypotheses are given. Jet pump has a cylindrical mixing chamber; efficiency and head loss caluclations are discussed. Part played by the diffuser is indicated. Comparison is made between a jet pump with a cylindrical mixing chamber and a converging mixing chamber constant piezometric height type with zero wall resistance.

From author's summary

Flow and Flight Test Techniques

(See also Revs. 3005, 3008)

3023. Smolderen, J. J., Condensation effects and air drying systems for supersonic wind tunnels, *AGARD Publications* no. 17, 79 pp., July 1956.

Based on his review of existing analytical and experimental studies, author develops a simple nomograph for determining local Mach number at which condensation shock occurs. Next he presents an outline of an unpublished analysis concerning nonuniformities in a wind-tunnel test section resulting from the presence of a condensation shock upstream of the test section. Graphs of these results together with the nomograph can be used to determine quickly an upper limit for disturbances for any stagnation dewpoint and temperature. Reviewer feels the upper limits so determined considerably overestimate actual variations in flow properties, especially angular deviations.

There is next presented an excellent review of the analytical techniques applicable to the design and operation of condensation and adsorption dryers, including a proposed new theory of dynamic adsorption. Finally, instruments for measuring humidity are discussed and a new type of hygrometer developed in Europe is explained.

J. S. Holdhusen, USA

3024. Vinsonneau, F., Comparison of measurements in flight and in wind tunnel of an airplane in subsonic flow (in French), *AGARD Publications* AG18/P8, 74-105, June 1955.

3025. Duddy, R. R., Some comparisons between wind tunnel model and flight test results on aircraft at high angles of attack, *AGARD Publications* AG18/P8, 107-125, June 1955.

The prediction of the damping of the lateral oscillation is shown to be fair at moderate lift coefficients but is poor at high lift coefficients and could probably be improved by tunnel measurement of damping derivatives.

Speed stability, which can be an important parameter in determining the minimum landing approach airspeed, could not be predicted with sufficient accuracy from tests at Reynolds numbers of 1.4×10^6 when the full-scale Reynolds number was about 12×10^6

Good correlation has been obtained between the divergence of the trailing edge pressure coefficient and the onset of buffet at high Mach numbers. This should prove a useful tunnel technique for the improvement of buffet boundaries on aircraft.

From author's summary

3026. Kuhn, R. E., and Hayes, W. C., Jr., Wind-tunnel investigation of effect of propeller slipstreams on aerodynamic characteristics of a wing equipped with a 50-percent-chord sliding flap and a 30-percent-chord slotted flap, *NACA TN* 3918, 72 pp., Feb. 1957.

3027. Mair, W. A., The distribution of pressure on an aerofoil, in a stream with a spanwise velocity gradient, *Aero. Quart.* **6,** 1, 1-12, Feb. 1955.

Pressure measurements were made at one section of an airfoil of constant chord spanning a wind tunnel. A flat plate was mounted in the tunnel upstream of the airfoil, so that the wake from the plate produced a spanwise velocity gradient at the airfoil. By traversing the plate across the tunnel the position of the wake could be altered relative to the pressure holes in the airfoil, so that the complete pressure distribution over the airfoil in the neighborhood of the wake could be found. The results showed that, because of the secondary flow produced by the interaction between the airfoil and the wake, the variation of pressure across the wake for a given chordwise position was very small, except close to the leading edge. Thus the lift coefficient, based on the velocity outside the wake, was nearly constant across the wake. The form drag coefficient, based on the same velocity, was considerably reduced in the wake. Even when the form drag coefficient was based on the *local* velocity of the stream, a considerable reduction was found in the wake.

From author's summary

3028. Brown, B. P., Ground simulator studies of the effects of valve friction, stick friction, flexibility, and backlash on power control system quality, *NACA TN* 3998, 45 pp., Apr. 1957.

Tests have been made on a power control system by means of a ground simulator to determine the effects of various combinations of valve friction and stick friction on the ability of the pilot to control the system. Various friction conditions were simulated with a rigid control system, a flexible system, and a rigid system having some backlash. For the tests, the period and damping of the simulated airplane were held constant.

The results show that, when valve friction was present in a rigid system, the introduction of stick friction was beneficial in that it restored some of the quality lost because of the valve fricton. When flexibility was introduced between the pilot and the source of stick friction, stick friction was still beneficial but, with flexibility between the source of stick friction and the valve, no benefits were obtained from stick friction. When backlash was introduced between the pilot and the source of stick friction, the valve-friction effect was not so objectionable as in the rigid system; stick friction improved this system still further. With backlash between the stick and the valve (±0.025 inch at the valve), even the frictionless system was undesirable, and the addition of any combination of the frictions reduced the control quality still further.

From author's summary

3029. von Glahn, U. H., Exploratory study of ground proximity effects on thrust of annular and circular nozzles, *NACA TN* 3982, 48 pp., Apr. 1957.

Scale-model studies were conducted with annular and circular nozzles to determine the effect of ground proximity on thrust. The studies were made using cold air, various nozzle-to-ground distances, nozzle-pressure ratios from 1.16 to 2.71, and several nozzle configurations.

The data show that proximity of the ground to an annular nozzle will cause a thrust augmentation. The thrust for an annular nozzle

compared to that of a circular nozzle of equal flow area will be of the order of 50% greater for a ratio of nozzle-to-ground distance to the annular nozzle base diameter of 0.2. The nozzle-to-ground distance at which thrust augmentation began (defined as critical nozzle-to-ground distance) was a function of nozzle-pressure ratio and the ratio of nozzle flow area to nozzle base area, typical values being of the order of 1.2 to 1.6 times the nozzle base diameter. Thrust augmentation was generally accompanied by an increase in the jet total pressure. This increase in jet total pressure increased with a decrease in nozzle-to-ground distance.

With a circular nozzle, the proximity of the ground will cause a decrease in thrust. This thrust reduction is a function of nozzle-to-ground distance, nozzle diameter, and nozzle-pressure ratio. The critical nozzle-to-ground distance for a circular nozzle is a function of nozzle-pressure ratio. For nozzle-pressure ratios of 1.16 and 2.71 the critical nozzle-to-ground distances in terms of the exhaust-nozzle diameter occurred at 0.92 and 0.57 diameter, respectively.

A brief discussion of the significance of these studies and their application to vertically rising aircraft is included.

From author's summary

3030. Jaquet, B. M., and Fletcher, H. S., Effects of fuselage nose length and a canopy on the static longitudinal and lateral stability characteristics of 45° sweptback airplane models having fuselages with square cross sections, *NACA TN* 3961, 47 pp., Apr. 1957.

A wind-tunnel investigation was made at low speed in the Langley stability tunnel to determine the effects of fuselage nose length (the fuselage fineness ratio varied from 7.41 to 10.18) and a canopy on the static longitudinal and lateral stability characteristics of a complete model having a fuselage with square cross sections, a 45° sweptback wing of aspect ratio 3 mounted low on the fuselage, and a 45° sweptback horizontal tail of aspect ratio 4 mounted slightly above the wing chord plane. The data were obtained through an angle-of-attack range of −10° to 32° and an angle-of-sideslip range of −24° to 24°.

From authors' summary

3031. Ibrahim, A. A. K., A graphical method for determining the coefficient of viscosity of Newtonian liquids using an oscillating cylinder viscometer, *ZAMP* **8,** 1, 74–75, 1957.

3032. Stalker, R. J., A study of the China-film technique for flow indication, *Aero. Res. Lab., Melbourne, Austral. Rep.* A. 96, 25 pp. + 6 figs., Oct. 1955.

Experiments on the mechanism of formation and the aerodynamic meaning of China-clay streak patterns are reported. Their formation is shown to be intimately connected with a sublayer of sludge in the liquid film, and the definition of the pattern is shown to depend on the viscosity of the carrier liquid. The direction of the streaks is shown to be the limiting direction of velocity on the surface, i.e., the direction of surface shear, unless the skin-friction coefficient is small compared with the gradient of the pressure coefficient, as, e.g., at separation. Attention is drawn to the confusing effects of surface tension near trailing edges, and of gravity on vertical surfaces.

The indication of boundary-layer transition is briefly reviewed and the effect on it of the viscosity of the carrier liquid is discussed. Some observations on the indication of the incidence of shock waves on solid surfaces are reported.

From author's summary

3033. Stalker, R. J., A note on the China-film technique for boundary layer indication, *J. roy. aero. Soc.* **60,** 548, 543–544 (Tech. Notes), Aug. 1956.

Book—3034. Handbook on aerial application in agriculture, College Station, Tex., A. & M. College of Texas, 1956, 146 pp. $2.50.

Thermodynamics

(See also Revs. 2836, 2946, 2977, 2995, 3014, 3015, 3016, 3020, 3022, 3023, 3051, 3060, 3067, 3088, 3089, 3090, 3096, 3103, 3108)

Book—3035. Mackey, C. O., Barnard, W. N., and Ellenwood, F. O., Engineering thermodynamics, New York, John Wiley & Sons, Inc., 1957, xvi + 428 pp. $7.95.

"This book is an outgrowth of 'Heat-power engineering' by William A. Barnard, Frank O. Ellenwood and Clarence F. Hirshfeld" points out C. Osborn Mackey, author of the present text. "I have enjoyed the privilege of working," he mentions in the preface, "under the direction of these three men, now deceased, who contributed so much to the knowledge in their field and to the training of young engineers; and I have tried to carry out their original objective, the sound and lucid presentation of the fundamentals of heat and power engineering."

The result is a modern undergraduate text book on thermodynamics of particular interest to mechanical engineers. In this respect, the selection and organization of the subject matter follows the modern trend of the seemingly endless array of similar texts available on the market today. The feature which distinguishes this book is that it is based on the classic on which so many of us have been brought up.

The over-all character of the book is reflected in the following list of chapters: (1) Historical Outline – 12 pages; (2) Temperature; Energy; First law of thermodynamics – 17 pages; (3) Processes and energy equations – 19 pages; (4) Second law of thermodynamics; Thermodynamic temperature; Entropy – 25 pages; (5) General thermodynamic equations – 8 pages; (6) Gases: Properties and processes – 47 pages; (7) Steady one-dimensional flow of ideal gases – 23 pages; (8) Properties of mixtures of ideal gases – 21 pages; (9) Ideal-gas reactions – 28 pages; (10) Compression of air and other gases – 26 pages; (11) Engine cycles-gas – 49 pages; (12) Vapors: Properties and processes – 31 pages; (13) Energy transformation in turbines – 28 pages; (14) Power cycles of vapors – 34 pages; (15) Refrigeration – 32 pages; and (16) Air conditioning – 20 pages. A. K. Oppenheim, USA

3036. Mercier, J., On the expression of mechanical work in thermodynamics (in French), *C. R. Acad. Sci. Paris* **240,** 6, 605–608, Feb. 1955.

3037. Weiss, A. H., and Joffe, J., Generalized correlation for effect of pressure, *Indust. Engng. Chem.* **49,** 1, 120–124, Jan. 1957.

3038. Lype, E. F., The determination of the equation of state from wave-front observations, ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56–A–129, 18 pp. + 4 figs.

Paper derives the mathematical relationships between the equation of state and wave- and shock-front characteristics in terms of differential equations. The development is complete, although somewhat over-complicated, and is generally applicable to one-dimensional wave or shock flows in the absence of relaxation phenomena. The practical utility of the method is likely to be small; a series of fifteen numerical or graphical integrations would be required to reduce a large set of experimental data to an equation of state. The inverse method of assuming a generalized equation of state and determining the coefficients directly from experimental data appears to remain preferable. F. Landis, USA

3039. Fischer, G., On phase transformations, *Amer. J. Phys.* **25,** 2, 100–108, Feb. 1957.

Paper seeks to clarify the definitions of the order of phase transformations in the case of systems composed of only one substance. First- and second-order phase transformations are discussed with the help of geometrical arguments applied to the intersection of free energy functions. This method also permits

analyzing the behavior of quantities such as the specific heat. As an application, second-order phase transformations of ferroelectric substances are discussed in some detail.

From author's summary by T. Y. Toong, USA

3040. Opfell, J. B., Sage, B. H., and Pitzer, K. S., Application of Benedict equation to theorem of corresponding states, *Indust. Engng. Chem.* **48,** 11, 2069–2076, Nov. 1956.

For nine different normal paraffin hydrocarbons from methane through decane, the following procedure was followed using the method of least squares for fitting the Benedict equation of state to existing experimental data: (1) Values of seven of the constants of the Benedict equation were found for each of three arbitrary values of the eighth. (2) Values of reduced composite coefficients for the Benedict equation in terms of reduced variables (p divided by critical p as a function of T divided by critical T and v divided by critical v) were found, yielding a single equation of state in consonance with the law of corresponding states. (3) Their results of (2) were modified for each gas by altering the quantities used as critical volume and critical temperature by factors which were in general different for the different gases (a departure from the law of corresponding states). (4) Using Pitzer's earlier proposal that the compressibility factor may be expressed as a sum of two terms—the first the reduced form of the Benedict equation, the second the same form multiplied by a factor ω whose magnitude is characteristic of the particular gas—, the corresponding fourteen "universal" coefficients were computed for each of three values of the remaining coefficient. The factor ω is log to the base 10 of the reduced vapor pressure at a reduced temperature of 0.7, minus one.

By comparison of root-mean-square deviations of calculated from observed values it is shown that method (4) is "comparable in its accuracy of prediction" to that of (1), although the deviations of the former range from 1.5 to 5 times those of the latter.

J. H. Keenan, USA

Book—3041. Mayhew, Y. R., and Rogers, G. F. C., Thermodynamic properties of fluids and other data, 2nd ed., Oxford, Basil Blackwell & Mott, Ltd., 1957, 16 pp.

A five-page table of properties of saturated liquid and vapor water and a three-page table of properties of superheated steam are taken from "Thermodynamic properties of steam" by Keenan and Keyes. Saturation values of viscosity, thermal conductivity, and Prandtl number are given. One page is devoted to the properties of ammonia and one to Freon-12. These along with even briefer tabulations for a dozen other substances are taken mostly from Hilsenrath, et al., *Nat. Bur. Stands. Circ.* 564, 1955. A page of data on mercury is taken from Sheldon, *Trans. ASME* 1949. English units—Fahrenheit, Btu, lb/in^2, etc.—are used throughout.

J. H. Keenan, USA

3042. Zdanovskii, A. B., The laws of viscosity change in the mixing of liquids (in Russian), *Zh. fiz. Khim.* **29,** 2, 209–218, 1955; *Ref. Zh. Mekh.* 1956, Rev. no. 2897.

A short survey is given of the available relationships for viscosity mixtures. A formula is adduced for the viscosity mixtures of liquids

$$\frac{\rho}{\eta} = x_1 \frac{\rho_1}{\eta_1} + x_2 \frac{\rho_2}{\eta_2} + \dots$$

(x_1, x_2 ... are the volume fractions of the mixed liquids; ρ, ρ_1, $\rho_2 \dots$, η, η_1, η_2 are the densities of the mixture and components and the viscosities of the mixture and components, respectively). This formula is similar to the known relationship for the viscosity of gas mixtures given by Mann [Mann, *Gas- und Wasserfach.* **73,** p. 570, 1930]. The attempt to give a hydrodynamic foundation to this formula on the basis of Poiseulle's and Stokes' laws is of a most primitive nature. On the basis of two organic systems and of three aqueous solution systems without chemical interaction, sufficiently good agreement between the experimental values of the viscosity of mixed solutions and those found by the new formula is demonstrated. The chemical interaction between certain components is represented on "kinematic flow-formation" diagrams.

Courtesy Referativnyi Zhurnal A. I. Golubev, USSR
Translation, courtesy Ministry of Supply, England

3043. Harrison, D., and Moelwyn-Hughes, E. A., The heat capacities of certain liquids, *Proc. roy. Soc. Lond.* (*A*) **239,** 1217, 230–246, Feb. 1957.

The heat capacities and adiabatic compressibilities of carbon tetrachloride, chloroform, methylene dibromide and methyl iodide have been measured between about −30 and 30 C.

The heat capacities at constant volume have been derived, and it is emphasized that these quantities apply to particular volumes existing at different temperatures. An isotherm for liquids, based on high-pressure data, has been used to obtain an expression for the effect of change of volume on the heat capacity at constant volume. This relation has been applied to mercury, carbon disulphide, carbon tetrachloride, chloroform and water. Satisfactory agreement has been obtained with the results found in other ways by Bridgman (1911, 1912) on mercury and water and by Gibson & Loeffler (1941) on carbon tetrachloride and water.

From the results found in this work on the resolution of the various energy contributions to the liquid heat capacities of polyatomic molecules other than water, it is concluded that the concept of molecular rotation about a preferred axis can explain most of the facts established. There remains, however, a structural contribution to the total heat capacity which is approximately R cal mole $^{-2}$ deg $^{-1}$. From authors' summary

3044. Challoner, A. R., and Powell, R. W., Thermal conductivities of liquids: new determinations for seven liquids and appraisal of existing values, *Proc. roy. Soc. Lond.* (*A*) **238,** 1212, 90–106, Dec. 1956.

A guarded hot-plate apparatus is described and used for absolute determinations of the thermal conductivities of liquids over the range 2 to 82 C. The liquids studied are water, heavy water (99.95% D_2O), glycerine, ethyl alcohol, toluene, medicinal paraffin, and carbon tetrachloride. For each liquid, graphical representation of the variation of thermal conductivity with temperature enables existing values to be compared with those of the present investigation. In general, the results of Riedel are in best agreement.

From authors' summary

3045. Liebermann, L., Air bubbles in water, *J. appl. Phys.* **28,** 2, 205–211, Feb. 1957.

The solubility of air bubbles is observed in a variety of experiments. Freely rising bubbles exhibit a solution rate more than twice that of bubbles which are stationary, i.e., trapped on the walls of the container. The theory of solution of stationary bubbles is given but the theory of a free bubble is difficult and has not been solved. Stationary bubble observations lead to a determination of the coefficient of diffusivity: 2.9×10^{-5} cm^2/sec at 27 C; the temperature dependence is considerable, obeying Einstein's equation relating diffusion and viscosity. The effect of surface contamination on diffusion is analyzed; bubble solution in the presence of contaminants is not greatly altered. Experiments are described showing that air bubbles of dimension less than 1 μ lodged on hydrophobic particles are not soluble and can exist indefinitely. It is shown that hydrophobic particle residues frequently remain after bubble solution, even in relatively pure water. These residues function as bubble nuclei for boiling or for cavitation. From author's summary

3046. Douglas, T. B., Specific heats of liquid metals and liquid salts, *Trans. ASME* **79,** 1, 23–28, Jan. 1957.

Paper reports on numerous measurements made at the National Bureau of Standards, in view of application to high-temperature heat exchangers. Author discusses experimental techniques and errors. Two examples of mixtures are given. When reduced to an atomic basis, the specific heats of these materials generally follow a simple rule, and can be predicted. R. Betchov, USA

3047. Rodionov, K. P., Certain thermodynamic properties of a solid under high pressure (in Russian), *Zh. tekh. Fiz.* **26,** 2, 6 pp., 1956. (translated from Russian by M. D. Friedman, 572 California St., Newtonville 60, Mass.)

3048. Styrikovich, M. A., Shitsman, M. E., and Miropol'skii, Z. L., Data on temperature conditions in a vertical water tube at near-critical pressures (in Russian), *Teploenergetika* **2,** 12, 32–36, Dec. 1955.

3049. Ladwig, E., Contribution to the design of a pressure reducing device (in German), *ZVDI* **99,** 3, 107–110, Jan. 1957.

3050. Martin, B. W., Improving gas turbine performance, *Engineering* **183,** 4747, 272–274, Mar. 1957.

Heat and Mass Transfer

(See also Revs. 2763, 2775, 2783, 2819, 2976, 2986, 2989, 3041, 3049, 3050, 3134)

Book—3051. Giedt, W. H., Principles of engineering heat transfer, New York, D. Van Nostrand Company, Inc., 1957, xiii + 372 pp. $8.25.

Book is written primarily for junior electrical engineering students with an attempt to emphasize physical interpretation of quantities and processes without neglecting analytical material. It comprises 16 chapters, consisting of an introductory chapter on energy transfer, three chapters on steady-state conduction, two chapters on fluid flow, three chapters on forced convection, one chapter on free convection, one chapter on boiling and condensation, two chapters on radiation, two chapters on unsteady state conduction and one chapter on heat exchangers; each chapter is prefaced by a quotation from an early scientist (Count Rumford, Lamb, Stefan, etc.) and/or a paragraph outlining the purpose of the chapter.

Chapter One presents a physical interpretation of conduction, convection, radiation, and thermal conductivity. The explanation of conduction in solids, liquids, and gases is amplified by some solid-state and kinetic theory. This is an excellent chapter. It provides a firm background for later detailed problem analysis.

Chapter Two is prefaced by a long quotation from Joseph Fourier on an explanation of heat flow. This is a short chapter devoted to a derivation of the three-dimensional Laplace heat flow equation from the fundamental Fourier-Biot equation. The derivation is given for rectangular coordinates. Final equations are given for cylindrical and spherical coordinates. The derivations for these systems are left as student exercises. Very good problems are provided at the end of the chapter. Author refers to the Laplace equation as the Fourier equation, which is confusing to those used to the terminology preferred by the reviewer.

Chapter Three is devoted to one-dimensional steady-state conduction. It includes the usual linear heat flow, radial flow, spherical flow and over-all heat flow cases, a discussion of thermal-conductivity measurement using cylindrical heat flow apparatus and a one-dimensional treatment of cylindrical rods or fins with application to the determination of heat loss from thermometer wells. The treatment of the classical rod heated on one end is just a little different from that of most authors. The discussion of over-all heat transfer is a little brief, being limited to an electrical analogy approach; however, this problem is taken up in more detail in the chapter on heat exchangers.

Chapter Four is devoted to two-dimensional steady-state conduction. The Laplace equation is solved for the case of a semi-infinite thin rectangular plate. This is followed by a discussion of graphical, numerical, and analogue techniques commonly used. Numerical methods are limited to Emmons' application of Southwells' relaxation technique. The discussion of shape factors includes graphical and electrical analogue techniques which are detailed and easily understood as is the treatment of Emmons' method.

In chap. Five, conventional, nonviscous flow is briefly treated. This chapter is intended for students without a background in fluid mechanics. Viscous flow, including skin drag, pipe friction, etc., is treated in chap. Six. Laminar convection heat transfer is discussed in chap. Seven. The common expressions for heat transfer to a flat plate are derived from the fundamentals. The concept of a thermal boundary layer and a hydrodynamic boundary layer are introduced, but it is not pointed out that in many cases they are of unequal thickness. The chapter is concluded with a treatment of laminar flow in tubes for the usual cases.

Chapter Eight is concerned with turbulent flow convective heat transfer. Similarity and dimensional requirements are utilized to determine the important parameters for correlating experimental data. Reynolds analogy is also presented. The usual equation for the various cases are given. Considerable space is devoted to turbulent flow theory. The chapter is concluded with a brief treatment of liquid metal heat transfer.

Chapter Nine is devoted to a discussion of two problems in forced convection. The first is the case of a circular cylinder in low velocity cross flow, including the effects of pressure gradients and flow separation. The second case concerns the high speed flow over the flat plate where frictional heat becomes significant. An important omission is the case of high speed flow parallel to the axis of a cylinder with different nose configurations. Students may inadvertently try to use the flat plate data for cones.

Discussion of the characteristics and analysis of natural convection is given in chap. Ten. Included is the application of the integral method to the solution of the natural convection boundary layer. The chapter is embellished with excellent interferograms of boundary layers together with a discussion of the application of the M. Z. Interferometer to natural convection boundary layer study. Also included are the usual equations for natural convection heat transfer between plates and cylinders with air. It should be pointed out that the equations are correct for small plates, but can give erroneous results for large plates; such as ceilings in rooms. Research of both the reviewer and the ASHAE Laboratory indicate, for example, that the heat transfer from ceilings by natural convection is only 1/3 that indicated by the usual equation. For more details on this subject, the reader is referred to HPAC **28,** 153–160, May 1956.

Chapter Eleven is a relatively short one concerning heat transfer during boiling and condensation. Considerable space is devoted to mathematical treatment of vertical condensing films. Boiling is discussed comparatively briefly. Chapter Twelve comprises a general discussion of radiation, including such topics as Kirchhoff's law, Planck's modification of Wien's law, radiation pressure and density, the Stefan-Boltzman law, emission, reflection, etc. Included are data for reflectivity, absorptivity, and transmissivity as functions of wave length, temperature and direction to the surface.

A discussion of methods for determining radiation heat exchange between black or grey surfaces is given in chap. Thirteen. The Hottel method of analysis is used extensively. A brief discussion is also given of the more recent network analysis of radiation, as advocated by A. K. Oppenheim. Chapter Fourteen is devoted to

cyclic heat transfer and transient temperature measurement with emphasis on thermocouple response. Also included is a brief discussion of the transient method for determing *b:* electrical solutions to transient and periodic problems.

Transient temperature distribution in solids is the subject matter for chap. Fifteen. Included are solutions for the four usual configurations for the usual ideal conditions of constant *b* and initially constant temperature distribution. Detailed mathematical solution is presented for an infinite slab of finite thickness with one insulated face. Heisler charts are presented and discussed for the cases frequently encountered, including the cylinder and the sphere. Four and one-half pages are devoted to the classical, but outmoded Schmidt graphical method. Since this text was written for electrical engineering students, it would seem appropriate to have included the application of digital computer technique to transient problems. Also, it would have been better, from reviewer's viewpoint, to discuss the use of the Schmidt method together with theoretical solutions for the initial temperature variation. This would have provided a more accurate method for the students.

The last chapter concerns heat exchangers. Included is a discussion of the over-all heat transfer coefficient, log mean temperature difference, parallel, counter, and cross flow heat exchangers, log mean temperature correction, pressure drop, heat exchanger effectiveness and heat exchanger design details. The material is embellished with a three-dimensional temperature distance plot. The number-of-transfer-units concept of Kays and London is also introduced. The discussion of typical heat exchanger design is good, and should give the student an insight to the practical side of heat transfer. The entire book is flavored with historical footnotes, and original works are emphasized throughout. In general, the book is well written and easy to read. It appears that the author has an excellent understanding of the fundamental principles. The book is very modern; for example, it includes the application of the integral method to free convection method, liquid metal heat transfer, and the latest Heisler charts. Although the text was written primarily for electrical engineering students, it would seem, to the reviewer, that too much detail was included. However, from a practical viewpoint, the potential market for the text is increased by including these details. The book could be adapted to heat transfer courses for mechanical engineering students if the material on fluid flow is greatly condensed. In general, this is not a reference book for full-time heat transfer research people, or for those who devote most of their time to research or teaching in heat transfer; rather, it should be a good book for those engineers who must periodically concern themselves with heat transfer problems and who do not wish to get lost in the maze of detail found in McAdam's wonderful book. There are many things about the text that the reviewer finds a little disagreeable as far as its use as a text; however, it is the reviewer's opinion that this is perhaps one of the best textbooks for undergraduate courses in heat transfer. The major criticism that this reviewer and others have raised is that the book demands a strong background in differential equations. This should not be a serious problem for electrical engineering students, but may cause some difficulty in other cases.

R. J. Mindak, USA

3052. Reeves, T. C., Thermal design in electronic equipment, *Mach. Design* **29,** 9, 84–93, May 1957.

Article describes a practical design guide on the thermal design problem; the electronic equipment thermal-design objectives; the procedures for minimizing heat generated by electrical and electronic components; the techniques for isolating heat from sensitive electronic components; and the methods of removing heat efficiently from electronic equipment. From author's summary

3053. Barzelay, M. E., and Holloway, G. F., Effect of an interface on transient temperature distribution in composite aircraft joints, *NACA TN* 3824, 51 pp., Apr. 1957.

Geometrically related structural joints representing typical skin-stringer cross sections were tested under radiant heating to simulate the effects of aerodynamic heating. Temperature histories for 15 2024-T aluminum alloy fabricated specimens and an equal number of integral control specimens were recorded for two different constant heat inputs, ranging from approximately 5 to 40 Btu/(sq ft)(sec). A maximum temperature rise of 450 F was attained in the specimens in 8 to 40 seconds of heating. There was no restraint or external loading applied.

The presence of an interface was found to have a significant effect on the temperature distribution in all geometries tested and thus must be considered in temperature calculations.

Interface conductance values were computed for each of the 15 fabricated specimens. These values ranged from approximately 150 to 1300 Btu/(sq ft)(hr)(°F) with a modal value of 300 Btu/(sq ft)(hr)(°F). Geometry and heating rate were found to have an effect on joint conductance by influencing the temperature distribution and thus the warping of the mating surfaces.

From authors' summary

3054. Nelson, K. L., Time-temperature cooling curves. Simplified determination of compound purity, *Anal. Chem.* **29,** 4, 512–518, Apr. 1957.

Purity specifications, which should be a routine adjunct to the reporting of physical and chemical properties, are most reliably obtained from time-temperature cooling curves. A simplified procedure using a compact, inexpensive apparatus is described. A new direct method for determining time at which freezing would have begun in absence of supercooling is presented.

From author's summary

3055. Parkus, H., Periodic temperature field in a wedge (in German), *Ost. Ing. Arch.* **10,** 2/3, 241–243, 1956.

Author computes the distribution of temperature in an infinite wedge, whose one wall is maintained at a constant temperature, the other having a specified periodically variable temperature $T = \theta e^{i\omega t}$.

Results of this paper can be useful for investigating thermal stresses in a cylindrical body with wedge-shaped section, if the the temperature of its sides varies periodically, e.g., in a dam whose water-side has a constant temperature while the temperature of its air-side varies by daytime and during different periods of the year. Z. Horak, Czechoslovakia

3056. Bublikov, E. I., Determining temperature distribution in walls by means of an electro-thermal analogy (in Russian), *Teploenergetika* **3,** 3, 10–13, 1956.

Temperature distribution in walls in problems of stationary heat transfer is controlled by differential equations with boundary conditions of the third kind (prescribed temperature and its normal derivative). Author describes an electrical analog device for such problems. The device consists of an electrolytic bath with arrangement of electrodes and resistances forming essentially a complex Wheatstone bridge. Choices of electrolyte, materials, and coatings of electrodes and spacing of electrodes were determined experimentally. Improper choices gave erroneous results which could not be reproduced even under identical conditions. Author claims that solutions obtained from his analog device differ by 2–3% from the exact solutions. T. Leser, USA

3057. Linke, J., Estimation of quickly varying temperatures and heat transfer of a gas to a metallic body (in German), *ZVDI* **98,** 35, 1925–1926, Dec. 1956.

Paper describes a sensitive thermoelement capable of measuring rapidly varying temperatures in metallic bodies, in particular on the inner surface of a firearm barrel. The thermoelement consists of a cylindrical block of steel with a boring in it containing a thin wire of nickel. The end of this wire is pressed against one face

of the steel block into a very thin junction whose thickness is 0.005 mm. Due to its extremely small thermal inertia this junction is capable of following very rapid temperature changes. Using theoretical formulas describing the temperature field in the semi-infinite body on the basis of the transient temperature pattern on its surface, it is possible to determine the total heat flux through the barrel. It is found that about 10% of the chemical energy of the explosive and 28% of the kinetic energy of the projectile are lost in the form of heat to the walls of the firearm.

A comparison is made between the measured temperature pattern and that calculated theoretically by L. W. Nordheim, M. Soodak and G. Nordheim. Although results do not differ essentially, it is found that even a better agreement could be brought about by properly manipulating the adjustable constants of this theory.

B. Zarwyn, USA

3058. Vodicka, V., Circular cylinder under periodic fluctuations of temperature, *ZAMP* **8,** 1, 53–64, Jan. 1957.

Author treats the case of the finite circular cylinder of homogeneous, isotropic material subjected to periodic variation of the fluid temperature adjacent to the surfaces. The ends and the cylindrical surface are considered to have boundary conditions of different frequency and different convection coefficients. Simple cases can be inferred from the general cases treated.

R. M. Drake, Jr., USA

3059. Schuh, H., Finite difference method for calculating transsient temperature distributions due to one-dimensional heat flow in simple and composite bodies (in German), *VDI-Forschungsheft* **23,** 459, 43 pp., 1957.

The well-known finite difference method is improved upon so that transient temperature distributions may be found due to heat flow which takes place normal or parallel to the surfaces of thick plates and thin-walled bodies of high conductance, respectively. Simple and composite bodies can be treated. The stability of solutions, discontinuities in the initial and boundary conditions, as well as other details are extensively dealt with. Sufficiently accurate solutions can be obtained with quite a small number of sections by a suitable method of satisfying boundary conditions and other precautions. Three examples of composite bodies are treated in detail to demonstrate the application of the method.

Reviewer finds the rules given to achieve maximum accuracy at minimum calculation time and to avoid oscillation of numerical results highly useful. Treatment is thorough and precise, although some assumptions made (e. g., rule of constant "moments of heat capacities") seem rather arbitrary.

L. S. Dzung, Switzerland

3060. Garwin, R. L., Calculation of heat flow in a medium whose conductivity varies with temperature, *Rev. sci. Instrum.* **27,** 10, 826–828, Oct. 1956.

It is shown that the heat flow in a single homogeneous medium of thermal conductivity $\sigma(T)$, between boundaries at temperatures T_2 and T_1, is the same as that for the same geometry in a medium of unit thermal conductivity and boundary "thermal potentials" $\sum(T_2)$ and $\sum(T_1)$, where $\sum(T) = \int_0^T \sigma(T')dT'$. This result, originally due to Kirchoff, is amplified through a study of its implications and by presentation of some applications of particular interest to cryogenicists.

H. G. Elrod, Jr., USA

3061. Mager, A., Leading edge cooling, *Jet Propulsion* **27,** 3, 293–295, Mar. 1957.

The temperature reached by a cooled leading edge of, e.g., a missile wing is computed under the following assumptions.

Case A—The heat capacity of the leading edge controls the temperature-rise rate under aerodynamic heating with constant heat input rate and fourth-power thermal radiation. Explicit solution is given.

Case B—The same as *Case A* except that a small (linearizable) time variation of the heat input rate is given. The solution is given as an integral permitting numerical solution by quadrature.

Case C—The same as *Case A* except the leading edge is hollow and carries coolant flow. In this case only the steady-state solution is sought. Again an explicit solution is given.

As an aid to use of the results, graphs of several pertinent functions are given.

H. W. Emmons, USA

3062. Czarnecki, K. R., and Sinclair, A. R., A note on the effect of heat transfer on peak pressure rise associated with separation of turbulent boundary layer on a body of revolution (NACA RM-10) at a Mach number of 1.61, *NACA TN* 3997, 13 pp., Apr. 1957.

An investigation has been made to determine the effect of heat transfer on the peak pressure rise associated with the separation of a turbulent boundary layer on a body of revolution [NACA RM 10] at a Mach number of 1.61. Tests were made over a Reynolds number range from 11.6×10^6 to 34.8×10^6 and with 0 to 120 F of cooling, which corresponds to a ratio of model-wall temperature to stagnation temperature of 0.96 (zero heat transfer) to 0.75. The stagnation temperature was approximately 570 F absolute. Boundary-layer separation was induced by means of forward-facing steps or collars at the base of the model and changes in heat transfer were obtained by cooling the model. The peak pressure rise was determined from shock angles measured from schlieren photographs.

The results indicate little or no effect of heat transfer on the shock angles associated with separation and, hence, on the peak pressure rise required to separate a turbulent boundary layer. The technique of using shock angles to determine the peak pressure rise for separation gave average results that were in good agreement with those of previous investigations in which measured pressure distributions were employed.

From authors' summary

3063. Farber, E. A., and Rennat, H. O., Variation of heat transfer coefficient with length, *Indust. Engng. Chem.* **49,** 3, 437–440, Mar. 1957.

Authors describe a method to measure surface temperatures and heat-transfer characteristics of a one-foot long stainless-steel tube having a 0.125-in. outside diam and a 0.095-in. inside diam.

To assure that convection currents were set up exclusively by the heated tube the investigation was carried out in a windowless room, with no steam or water piping. Investigations were carried with power inputs of 310, 693, and 1100 watts. With each power input the temperature distribution was determined for the tube position with the horizontal at 0°, 30°, 60°, 75°, and 90°.

Authors' conclusions are that small-diameter uniformly heated tubes, not exceeding 1 ft, no in. in length, lose heat more rapidly in a horizontal position than in vertical.

At the same rate of heat transfer, horizontal tubes have a slightly larger film coefficient than the portion of vertical tubes behind the transition region.

W. Green, USA

3064. Nonweiler, T. R. F., Skin heating during re-entry of satellite vehicles to the atmosphere, *J. Brit. interplanetary Soc.* **16,** 1, 10–21, Jan.-Mar. 1957.

By paying special attention to the wing design and altitude of flight, it is possible to insure that the highest temperature reached at the leading edge of the wing of an aircraft, in level flight at speeds of the order of the circling velocity, need be no more than 1000 C. Formulas and charts are presented to enable the actual skin temperature close to the nose to be predicted, for a wedge-shaped wing, in terms of skin thickness and conductivity.

From author's summary

3065. Esgar, J. B., Schum, E. F., and Curren, A. N., Effect of chord size on weight and cooling characteristics of air-cooled turbine blades, *NACA TN* 3923, 37 pp., Jan. 1957.

An analysis has been made to determine the effect of chord size on the weight and cooling characteristics of shell-supported, air-cooled gas-turbine blades. In uncooled turbines with solid blades, the general practice has been to design turbines with high aspect ratio (small blade chord) to achieve substantial turbine weight reduction. With air-cooled blades, this study shows that turbine blade weight is affected to a much smaller degree by the size of the blade chord.

The heat-transfer analysis shows that considerable savings in coolant flow are possible by utilizing a smaller number of large-chord blades rather than a larger number of small-chord blades with constant blade solidity. Generally, turbines with a blade chord of only 1 inch require about twice as much coolant as turbines with 3-inch-chord blades for a turbine-inlet temperature of 2500 R. As the blade chord is reduced below 1 inch, such as might be encountered in small-diameter engines, the coolant-flow requirements increase very rapidly. The coolant flow required for a blade with ½-inch chord may be more than twice that required for a 1-inch-chord blade. In addition to the high coolant flows required for the small-chord blades, they often are unable to pass the required coolant flow at the pressure levels encountered in engine operation. Although this investigation was conducted specifically on corrugated-insert blades, the trends of the results are believed to be general. The study shows that, in air-cooled-turbine design, efforts should be made to use blades with as large a chord as appears feasible with regard to disk stress and aerodynamics. From authors' summary

3066. Priestly, C. H. B., Convection from the earth's surface, *Proc. roy. Soc. Lond.* (*A*) **238,** 1214, 287–304, Jan. 1957.

Nonlinear temperature profiles in the lowest 30 m over heated ground can give rise to convection plumes, which can maintain their existence without heat supply. Plumes form in elongated strips oriented downwind, and have cross sections which approach circular shape as the negative Richardson number increases.

Average heat flux by virtue of such plumes is found from observations to conform to the theoretical law of free convection proposed by Priestly, which provides that the flux is inversely proportional to the square root of the absolute temperature in the surface layer, directly proportional to the square of the elevation above the ground, and directly proportional to the 3/2 power of the gradient of potential temperature. Free convection becomes significant compared with forced convection when the Richardson number reaches −0.011. R. O. Reid, USA

3067. Novikov, I. I., Soloviev, A. N., Khabakhnasheva, E. M., Gruzdev, V. A., Pridantzev, A. I., and Vasenina, M. Ya., The heat-transfer and high-temperature properties of liquid alkali metals, *Soviet J. nuc. energy* 4, 3, 387–408, Mar. 1957.

The heat-transport properties of liquid sodium in turbulent flow through circular copper and nickel tubing have been investigated and an empricial formula determined. The thermal resistances at the interfaces between liquid sodium and solid copper, nickel and stainless steel were also investigated. Methods of measurement of the viscosity, thermal diffusivity, and the density of liquid metals are described. Data on these properties of the liquid alkali metals (sodium potassium lithium, Na-K eutectic alloy) are given throughout a wide temperature range. From authors' summary

3068. Brown, H. E., Amstead, B. H., and Short, B. E., Temperature and velocity distribution and transfer of heat in a liquid metal, *Trans. ASME* **79,** 2, 279–285, Feb. 1957.

Results of these experiments on a cooled turbulent stream of mercury are of value in understanding the phenomenon of heat transfer in liquid metals. Temperature and velocity traverses were made across a 1.6-in.-ID nickel pipe over *Re* moduli of 250,000 to 800,000 under a constant Prandtl number of 0.02 and constant heat flux. Cooling section was 25 ft long, jacketed with 2½-in. brass tube. Authors conclude that in the *absence* of an interfacial resistance, the Martenilli-Lyon analogy represents the current data reasonably well, when allowance is made for the variation of α (ratio of eddy diffusivity for heat transfer to eddy diffusivity for momentum transfer) with *Re* number. Idea of interface resistance for heat transfer to mercury is suggested because values of Nusselt moduli are approximately greater than those from measurements of solid-wall temperature. The α is reasonably constant over the radius except in the vicinity of the wall but increases from 0.7 to 0.9 when *Re* number varies from 250,000 to 800,000.

Reviewer judges that the experimental equipment was assembled with care and foresight. H. Majors, Jr., USA

3069. Person, R. A., Compilation of radiation shape factors for cylindrical assemblies, ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56–A–144, 19 pp.

Paper tabulates geometrical view factors for a number of assemblies involving cylinders and plane surfaces. Results are particularly useful in furnace design problems. While some of the work is new, most of the results have appeared previously in the literature. Authors have conveniently compiled the shape factors for the bulk of the cylindrical assemblies which are of practical interest. W. Daskin, USA

3070. Cantle, G. S., El Din Aref, M. N., and Sakkal, M. F., The measurement of a probe radiometer of radiant heat flux distribution at curved surfaces, *J. Inst. Fuel* **29,** 187, 327–332, Aug. 1956.

Paper describes a small "net exchanger" or "probe" radiometer, and presents experimental data obtained for measurement of radiant heat flux to tubes. Excellent agreement is obtained between the total heat flux obtained from a radiometer traverse of the tube and that calculated from the heat absorbed by the water flowing through the tube.

The radiometer itself consists essentially of a small block of refractory material. The difference in irradiation of the opposing faces of the block produces a temperature difference which is related to the net radiation flux. The net radiant flux can be computed from the thermal conductivity of the refractory material, the emissivities of the two surfaces and the geometrical factors involved, but actual calibration of the device is preferable due to uncertainties in these characteristics.

The basic instrument is not new, as similar instruments have been utilized by Hottel at M.I.T. In addition, a low-temperature, convection-compensated, net exchange radiometer intended primarily for meteorological observations has been described by Gier and Dunkle, *AIEE Trans.* **70,** 1951. R. V. Dunkle, USA

3071. Goodman, S., Radiant-heat transfer between nongray parallel plates, *J. Res. nat. Bur. Stands.* **58,** 1, 37–40, Jan. 1957.

Spectral emissivity data were used to compute radiant heat transfer for aluminum and Inconel in the range 300 C to 600 C, and 300 C to 1000 C, respectively. Gray-body assumptions were found to give errors as high as 15% for aluminum and 25% for Inconel. It is shown that, in box-beam construction, radiation cannot be neglected in relation to conduction, even in aluminum, and that there is need for accurate spectral emissivity data for aircraft materials with different surface conditions, since, at present, errors in the emissivity values may cause greater errors than gray-body assumptions. A. Whillier, South Africa

3072. Sherman, R. A., Heat transfer by radiation from flames, ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56–A–111, 16 pp.

3073. Ziegler, E., Kiln-shell temperature and radiation losses in rotary kilns (in German), *Zement-Kalk-Gips* **9,** 5, 194–200, May 1956.

3074. Davies, D. R., and Bourne, D. E., On the calculation of heat and mass transfer in laminar and turbulent boundary layers. I. The laminar case, *Quart. J. Mech. appl. Math.* **9,** 4, 457–467, Dec. 1956.

Paper presents a method for approximate solution of the transfer equations for laminar boundary layers when the free-stream velocity varies as x^m; here x is the distance downstream from the leading edge of the momentum boundary layer and $0 \leq m \leq 4$. The approximation consists of a power-law representation (to within 3–7%) of the exact velocity profile; subsequent solution is exact. For cases considered, errors in predicted coefficients are only 2 to 3%, considerably less than those obtained using Lighthill's approximate method [AMR **4,** Rev. 2612]. In some cases the answer reduces to functions which are already tabulated, but more often it is in a form which would require extensive numerical calculations for actual use. R. R. Hughes, USA

3075. Davies, D. R., and Bourne, D. E., On the calculation of heat and mass transfer in laminar and turbulent boundary layers. II. The turbulent case, *Quart. J. Mech. appl. Math.* **9,** 4, 468–488, Dec. 1956.

Method of the first paper [see preceding review] is extended to handle transfer into turbulent boundary layers, by introducing power-law approximations not only for velocity profiles, but also for eddy viscosity. Authors point out importance of laminar and transitional sublayers for transfer, in spite of their thinness relative to the whole boundary layer. When applied to the evaporation experiments of Davies and Walters [AMR **6,** Rev. 1772], method predicts evaporation rate within about 10%. Reviewer feels this confirmation is not too satisfactory since some parameters for diffusivity, etc., were obtained from the same experiments; further comparisons are needed to prove the general validity of the method. Moreover, reviewer questions authors' assumption of equality of diffusivities for momentum, heat, and mass transfer.

R. R. Hughes, USA

3076. Sogin, H. H., Sublimation from disks to air streams flowing normal to their surfaces, ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56-A-115, 12 pp.

Mass transfer by sublimation from 4-in.-diam naphthalene disks to the stagnation regions of impinging jets of air was calibrated with heat transfer by convection in an identical configuration. Within the limits of the experimental reproducibility, all results were brought into a single correlation using Colburn's formulation of the heat-mass analogy. The calibration was then employed to obtain mean coefficients of heat transfer on disks with free edges. This part of the investigation was performed using two sorts of air streams; a 10-in.-diam jet discharging freely into the atmosphere and a 5-ft-diam stream in a closed throat of a wind tunnel. The air speeds ranged from 32 to 293 fps, and the disks, made of naphthalene or of para-dichlorobenzene, were 2.25 and 4 in. in diam. The results of this part of the investigation may be represented by the equation

$$j_{\frac{D}{p}} = \frac{GD}{\mu f} = 1.08$$

with a probable error of ±3%. Including Powell's work on evaporation of water from disks, the equation covers a range of Reynolds number from 2000 to 600,000 with a maximum deviation of about ±10% from the experimental points. The results of this work possibly may be of some general interest with regard to heat transfer at the stagnation region of a surface of revolution and perhaps may be of some use in dew-point or water-content instrumentation.

From author's summary

3077. Landsberg, R., Heat and mass transfer on the outside of cool air ducts, *Bull. Res. Counc. Israel* **5c,** 2/3, 147–150, May/June 1956.

Consideration is given in the present paper to the effect of condensation on heat transfer from air ducts. High external humidity plus condensation tends to increase the rate of heat transfer as compared to that occuring with no condensation. Equations for both mass transfer and heat transfer are developed and extended to the case of air-conditioning practice. L. Lapidus, USA

3078. Ogata, Y., and Tsuchida, M., Linear boiling point relationships, *Indust. Engng. Chem.* **49,** 3, 415–417, Mar. 1957.

A simple equation for predicting boiling points of a wider range of organics has been applied to 600 compounds; calculated results for 80% fall within 2° C of experimental values.

From authors' summary by W. M. Rohsenow, USA

3079. Vos, A. S., and van Stralen, S. J. D., Heat transfer to boiling water-methylethylketone mixtures, *Chem. Engng. Sci.* **5,** 50–56, 1956.

An apparatus has been designed for determination of heat transfer to boiling mixtures of water-methylethylketone under atmospheric pressure, using the central portion of a horizontal platinum heating wire at the same time as a resistance thermometer, according to the method of McAdams.

A hysteresis effect observed in mixtures containing an excess of methylethylketone was avoided by keeping the annealed wire immersed in the liquid for a sufficiently long time at room temperature. The reference value of the resistance thermometer was also measured with immersed wire at the boiling temperature of the liquid.

The entire region of heat transfer up to the maximum of nucleate boiling was measured for some mixtures including the pure components (0, 4.2, 20, 52, 88.5, and 100% wt of methylethylketone). With increasing concentration of methylethylketone a gradual shift of the curves to lower heat transfer occurred, except for the 4.2% and 20% mixtures, where a noticeably high maximum heat flux of 2.5 and 2.0 times that of water was found. Since it was also observed with heating wires of different metals and alloys, this peculiar behavior can be considered to be a characteristic property of the liquid mixtures themselves. From authors' summary

3080. Borishanskii, V. M., The problem of generalizing test data on the cessation of ebullition in a large volume of liquid (in Russian), Symp. Heat transmission and aerohydrodynamics, 169–181, Mashgiz, 1955; *Ref. Zh. Mekh.* 1956, Rev. no. 2949.

An examination is made of the boiling of water in a large volume. A distinction is made between the zone of medium heat loads for which the behavior of the vapor bubbles formed is characteristic, and the zone about the critical heat loads.

Analyzing the hydrodynamic model of the crisis of boiling starting from equations, proposed by S. S. Kutateladza, author examines the boundary layer of a boiling liquid at the approach to the crisis, as a system of jets (streams) of a liquid surrounded by vapor. The thickness of this layer is assumed equal to the separation diameter of the bubble. The crisis phenomenon is represented as a problem of disturbing the steady flow of a jet of liquid in a medium of gas moving co-axially with it; in this, axial-symmetrical oscillations on a circular cylindrical jet are assumed, and the solution of the problem is limited to finding the connection between the increment χ_n and the oscillation wave length λ_n. A similarity law for the critical heat load is found. The system of similarity criteria is not directly found from the initial equations and boundary conditions, but from the integral of this system.

As a result of constructing an arrangement of the phenomenon, combined criteria are obtained which the author considers characteristic for describing the critical conditions of boiling in a large volume for various liquids

$$K = \frac{q_{\kappa p}}{r\gamma''^{0.5}[g^2\sigma(\gamma-\gamma'')]^{0.25}}, \quad N = \frac{\gamma\sigma^{1.5}}{g\mu^2(\gamma-\gamma'')^{0.5}}$$

The treatment of the tests enables all the most reliable test data known in the appropriate literature to be reconciled within the limits of variation of the determining criterion N between 20,000 and 360,0000, the formula $K = 0.13 + 4N^{-0.4}$ being recommended.

Courtesy Referativnyi Zhurnal P. I. Povarnin, USSR
Translation, courtesy Ministry of Supply, England

3081. Bobco, R. P., and Gosman, A. L., Promotion of dropwise condensation of several pure organic vapors, ASME Spring Meet., Birmingham, Ala., Apr. 1957. Pap. 57-S-2, 6 pp.

The phenomenon of dropwise condensation of pure vapors has been observed heretofore only with steam. This paper describes the results achieved in inducing dropwise condensation of isooctane, ethanol, carbon disulphide, and several other organic substances through the use of various fluorochemicals as promoters. Although no heat-transfer data are available, the question of the practicability of using these promoters is discussed.

From authors' summary

3082. Gelperin, N. I., and Zilberg, V. I., Determination of the heat transmission coefficients from condensing vapours to liquids (in Russian), *Trudi, Mosk. in-ta tonkoi khim. tekhnol.* no. 5, 18-26, 1955; *Ref. Zh. Mekh.* 1956, Rev. no. 2925.

An attempt is made to facilitate the practical solution of problems relating to the determination of coefficients of heat transmission from condensing vapors to liquids with retention of their aggregate state and with boiling.

For this purpose in the equation generally accepted in courses on heat transmission

$$\alpha_1 = C \sqrt[4]{\frac{\gamma^2 \lambda^3}{\mu}} \sqrt[4]{\frac{r}{L(t_1 - \theta_1)}}$$

(in which t_1 is the temperature of condensation of the saturated vapor, θ_1 the wall surface temperature), authors refer the constants γ, λ, μ to the temperature of the saturated vapor (instead of the wall temperature). This results in an error of + 2.2%, which is permissible in practice.

The problem is reduced to the graphical solution of the equation relative to the heat transmission coefficient from the condensing vapor to the liquid. The solution which is given in the form of nomogram is valid both for the case of heat transmission to a nonboiling liquid and for the case of a variation of the aggregate state of the latter. In this the coefficient of thermal emission from the surface of the wall to the boiling liquid is dependent on the temperature of the walls and is determined from the formulas of G. N. Kruzhilin and M. A. Mikheev. The nomogram which is intended for a determination of the heat transmission coefficients from the condensing vapor to the boiling liquid consists of eight graphs drawn for working temperature differences as follows: 10, 15, 20, 25, 30, 35, 40, and 45°. In an appendix, two examples are solved by the aid of these nomograms.

Courtesy Referativnyi Zhurnal V. N. Bogin, USSR
Translation, courtesy Ministry of Supply, England

3083. Gardner, K. A., The effect of condensate reheat on mean temperature difference in feedwater heater subcooling zones, ASME Ann. Meet., New York, N. Y., Nov. 1956, Pap. 56-A-69, 6 pp.

Heat leakage through the subcooling zone wall in combination feedwater heaters tends to defeat one purpose of the zone; namely, to subcool the condensate. Equations are presented for the determination of the mean temperature difference, feedwater and condensate-outlet temperatures, and minimum subcooling terminal approach under such conditions. These are given in terms of the relative heat-transfer capability of the zone envelope as compared to the tube surface enclosed.

W. L. Sibbitt, USA

3084. Carte, A. E., The freezing of water droplets, *Proc. phys. Soc. Lond. (B)* **69,** 442, 1028-1037, Oct. 1956.

A microscope method was used to study the freezing of individual water droplets 9 to 33 microns in diameter formed by condensation on various surfaces and protected with a film of silicone oil. The lowest freezing temperatures were found to be independent of the six surfaces used but dependent upon the volume of the water droplets and the rate of cooling. The results were correlated with those of other observers and it was concluded that homogeneous nucleation occurred in the lowest freezing droplets. Values of the surface free energy for a water-ice interface were calculated.

From author's summary

3085. Gaylord, E. W., Hughes, W. F., Appl, F. C., and Ling, F. F., On the theoretical analysis of a dynamic thermocouple, ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56-A-86, 4 pp.

Paper deals with a theoretical analysis of the indicated emf of a dynamic (Herbert-Gottwein) thermocouple in relation to the individual Seebeck emf's at numerous junctions over the contact interface of a sliding pair. By ignoring the inductive and capacitive effects during making and breaking of the minute junctions, steady state is regarded to exist electrically. From basic principles of thermoelectricity, authors deduce that the emf measured by a potentiometer satisfies Laplace's equation for both members of the sliding pair. If, in addition, the two members are identical in geometry, having equal electrical conductivity, and the leads are symmetrically located with respect to the interface, the potential at any contact is the Seebeck emf corresponding to its temperature. For two semi-infinite rubbing bodies with randomly distributed real areas of contact, which are small compared to the distances among them, the indicated potential with leads placed at a large distance away from the sliding interface is the average of the Seebeck emf's, weighted by the square root of the contact areas.

While the conclusion drawn differs from that reported in an earlier publication ["The mechanism of crater wear of cutting tools," ME Tech. Report ORD-1121-2, University of Illinois, Aug. 1955], reviewer believes that the analysis is among first of the kind and is thus valuable.

B. T. Chao, USA

3086. Rea, S. E., and Ablow, C. M., Transient air temperatures in a duct, ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56-A-70, 6 pp.

Theoretical calculations and experimental measurements of transient air temperatures in a duct are compared. Paper applies to air temperature control systems in aircraft. Gas temperature fluctuations in the duct are induced by blending hot and cold air streams with a modulating valve. Total air flow is kept constant.

Simplified equations of air flow and heat transfer in a duct are developed, and high-speed computing methods for solving equations are outlined. Experimental results and theoretical calculations for gas and duct wall temperatures resulting from pulses of heated gas passing through duct agree fairly well with each other. The duct walls participate in downstream temperature variations in an important way. Differences between theory and experimental results are assumed to be due to oversimplified theory, uncertainties in the heat-transfer coefficient, and errors in experimental measurements.

T. P. Clark, USA

3087. Trigger, K. J., Campbell, R. K., and Chao, B. T., A tool-work-thermocouple compensating circuit, ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56-A-90, 5 pp.

Authors propose a compensating circuit which is able to nullify errors of inconsistency in thermoelectric characteristics of calibration bar and cutting inserts on indicated tool-chip interface temperature. The flow of thermoelectric current of a copper-constantan couple in a closed circuit is used to compensate the parasitic emf introduced by dissimilar lead materials attached to the cutting insert.

Satisfactory test results are given.

C. Codegone, Italy

3088. Godridge, A. M., Jackson, R., and Thurlow, G. G., The industrial measurement of gas temperature, *Trans. Soc. Instrum. Technol.* **8,** 3, 103–132, Sept. 1956.

Paper is primarily concerned with the practical problems of accurate temperature measurement in high-temperature gas streams, e.g., steam-boiler superheater section, preheater, and exhaust sections of various furnaces.

The first part of the paper discusses the possible serious errors which may result when using sheathed thermocouples, resistance thermometers, and the like; it also discusses more accurate methods using suction pyrometers, total heat meters, or pneumatic venturi pyrometers. Data are provided showing the nonuniform temperature distribution patterns occurring across ducts conveying high-temperature gas streams. The second part of the paper provides practical examples of performance of a wide variety of temperature-sensing instruments over a temperature range up to about 2800 F.

The significant contribution of this paper is the discussion of preliminary results of a pneumatic-venturi pyrometer—a water-cooled device containing two venturi nozzles in series with a finite cylindrical section between. The gas stream is forced through the instrument by suction. This device shows promise for accurate measurement of instantaneous temperatures.

The chief weakness of this paper, in reviewer's opinion, is a lack of discussion of methods for calculating the magnitudes of errors with such devices as sheathed thermocouples. Most of the errors, exclusive of that resulting from nonuniform temperature distributions, may be calculated with reasonable accuracy using elementary heat-transfer principles.

It is significant to note that this paper of some 25 pages was accompanied by 7 pages of very interesting discussion.

R. Mindak, USA

3089. Haase, V. R., Theory of thermoelectricity (in German), *Z. Naturforsch.* **11a,** 9, 681–684, Sept. 1956.

Author discusses several relations between thermoelectric coefficients, which are directly deduced from irreversible thermodynamics. A simple formula relates the heat of transfer of electrons to the difference between the thermal conductivity in absence of electric field and the thermal conductivity in the stationary non-equilibrium state (absence of electric current). As a consequence of the definite positive character of the entropy production, author determines an upper bound to the value of the heat of transfer, proportional to the thermal conductivity and electric resistivity of the metal. Finally, the well-known derivation of Thomson's classical relations is discussed in a simple case.

R. Balescu, Belgium

3090. Simmons, F. S., and Glawe, G. E., Theory and design of a pneumatic temperature probe and experimental results obtained in a high-temperature gas stream, *NACA TN* 3893, 41 pp., Jan. 1957.

Article presents a review of the theory and design considerations for pneumatic-type temperature probe. An experimental unit is described with emphasis on design procedures. Tests were conducted in a gas stream over a temperature range of 1600 to 4000 R to compare the pneumatic probe instrument with an aspirated chromel-alumel thermocouple, a bare wire platinum-platinum rhodium thermocouple, and a sodium line reversal unit. Reasonable agreement was attained. Information should be useful in guiding the design and application of pneumatic probe for gas temperature measurements.

D. Bendersky, USA

3091. Fischer, T., and Schalk, E., Measurement of surface temperature of moving machine parts (in Hungarian), *Mérés és Automatika* **3,** 2, 33–40, Feb. 1955.

Authors present a survey of the known surface temperature-measuring methods based on thermal conduction and radiation, and they examine the conditions of their application in the case of moving surfaces. They describe the thermocouple connected with auxiliary plates as a new instrument which J. Beczkoy has developed. Beczkoy has precedence for the surface temperature-measuring instrument based on radiation compensation, described in *Technische Rundschau* [**45,** 18, 1–3, May 1953], because he presented it in 1951 at the Congress for Measuring Techniques in Budapest.

Authors then describe their instrument, measuring with a thermistor, by means of thermal radiation and convection at temperatures of 70 to 130 C, the limit of error being ± 2 C. This simple plant instrument designed originally for a paper-mill, operating in vaporous atmosphere, does not touch the cylindrical surface moving at a speed of 60–160 m/min. The fluctuation of temperature as registered by mechanism is ± 1 C.

Paper calls attention to the fact that, in a given case, it might be necessary to consider the heat inertia of the thermistor. The data of the measuring circuit must be chosen in such a way that it does not alter the accuracy of the measurement. In the case of measuring the temperature of bodies with smaller mass, the measurement would be altered by the temperature of surroundings.

Summarizing, they have constructed a simple new instrument which can be used under definite circumstances.

G. Pattantyus, Hungary

3092. Gunther-Mohr, G. R., and Triebwasser, S., Simple constant-temperature oven and control system, *IBM J. Res. Development* **1,** 1, 84–89, Jan. 1957.

A number of laboratory measurements require a constant and uniform ambient temperature. A thermocouple-monitored system consisting of an oven, a stable reference source and a chopper-amplifier controller unit has been developed. This system provides a stable and uniform temperature, ±0.1 C from 200 to 1050 C in a cylindrical region 5 cm in diameter and 12 cm long. Each of the parts of the system is discussed and their operation as an integrated whole considered.

From authors' summary

3093. Anderson, J. B., Fuel elements for nuclear reactors, *Trans. ASME* **79,** 1, 29–33, Jan. 1957.

Author describes and discusses current and proposed nuclear reactor fuel element shapes: plates, cylinders, wires, twisted ribbons, spheres, and saddles. Basic considerations are outlined, including heat-transfer coefficients, cooling surface per unit of volume, and extent of flow-mixing and flow nonuniformity obtainable with the various designs. Comparisons based on constant pumping power or hot-spot temperature are not provided.

C. F. Bonilla, USA

3094. Sullivan, L. J., Ruppel, T. C., and Willingham, C. B., Packed thermal diffusion columns—effect of changes in annular spacing and packing density, *Indust. Engng. Chem.* **49,** 1, 110–113, Jan. 1957.

The effect of varying annular spacing and packing density has been studied for the batch separation of organic liquids in concentric tube columns packed with glass wool. The test mixture used was a 50 volume % mixture of the *cis*- and *trans*-decahydronaphthalenes. The mixture is shown to be a good test mixture for column evaluation in that it separates in a regular manner and is difficult to separate completely. The comparative ease with which mixtures of *n*-hexadecane and decahydronaphthalene or *n*-hexadecane and methylnaphthalene are separated is illustrated. A complex relation is shown between percentage separation and annular spacing, whereas, within limits, a direct relation is found between percentage separation and packing density.

From authors' summary

3095. Dotson, J. A., Holden, J. H., and Koehler, W. A., Rate of steam-carbon reaction by a falling particle method, *Indust. Engng. Chem.* **49,** 1, 148–154, Jan. 1957.

This work was undertaken to obtain kinetic data under the following conditions: temperature range, 1800 to 2500 F; carbon particles size, 200- to 230-mesh; and sufficient excess of steam so that the change in the gas composition was negligible. Preheated carbon particles and steam flowed concurrently through an externally heated tube. The carbon conversion was determined from the difference in weight of the entering and leaving carbon. The reaction rates were extrapolated to zero conversion.

Two types of carbon were investigated—petroleum coke and electrode graphite. For both types of carbon, a surface or chemically controlled reaction rate is indicated because activation energies in the order of chemical reactions were obtained and because rectilinear correlations on an Arrhenius plot were obtained. However, the rates obtained for the two carbons were widely divergent, and the type of variation with burnoff for the two carbons was also different. From authors' summary

3096. Rottenburg, P. A., The control of reactions at elevated temperatures, *Trans. Inst. chem. Engrs.* **35,** 1, 37–50, 1957.

The problem of temperature control in multitubular reactors and the associated difficulties in using various heat-transfer media are discussed. A rapid method of evaluating the transfer properties of heat-transfer media is presented. The control of a multitubular reactor operating at 400 C with endothermic and exothermic reactions is considered in detail, and estimates are presented showing the relative costs using various heat-transfer media.
From author's summary

3097. Larinoff, M. W., Cooling towers for steam-electric stations selection and performance experiences, ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56-A-59, 11 pp.

3098. Weber, P., The heat recovery from clinker cooling (in German), *Zement-Kalk-Gips* **9,** 5, 200–203, May 1956.

3099. Bergstrom, S. G., Freezing and thawing tests on cement mortar, *Swedish Cem. Concr. Res. Inst. Bull.* no. 32, 3–23, 1955.

3100. Hall, A. A., Advancing temperature frontiers, *AGARD Publications* AG20/P10, 39–41, June 1955.

3101. Hartwig, F. W., Bartsch, G. A., and McDonald, H., Miniaturized heat meter for steady-state aerodynamic heat-transfer measurements, *J. aero. Sci.* **24,** 3, 239 (Readers' Forum), Mar. 1957.

3102. Crawford, C. B., and Legget, R. F., Ground temperature investigations in Canada, *Engng. J. Montreal* **40,** 3, 263–269, Mar. 1957.

3103. Hijmans, D., and Norenburg, J. C., The use of the heat pump in distillation (in Dutch), *Ingenieur* **68,** 46, Ch. 73–Ch. 80, Nov. 1956.

Up till now little attention has been paid to the use of the heat in distillation processes. However, under certain conditions the application of a heat pump in distillation may yield a considerable saving in energy consumption which outweighs the extra cost due to higher capital investment. From authors' summary

Combustion

(See Revs. 3069, 3072, 3073, 3095, 3096, 3114, 3138)

Acoustics

(See also Rev. 2943)

Book—3104. Furrer, W., Room and architectural acoustics for architects [Raum- und Bauakustik für Architekten], Basel, Birkhauser Verlag, 1956, 200 pp.

The technical literature is rich in the number of papers dealing with various phases of the theory of architectural acoustics. Several of these investigations, however, are reported in a manner understandable only to the workers in the field. There is a need for a book for non-specialists and one in which the essential implications of recent investigations in architectural acoustics are discussed.

As the title indicates, Furrer's delightful book is written for architects. In the preface, author states that no previous background in acoustics is assumed on the part of the reader. The subject matter has little mathematics in it, special emphasis being placed on qualitative discussions of practical problems. The content of the book follows closely a series of lectures which the author gives in a course on architectural acoustics at the Technischen Hochschule in Zurich.

The book is divided into 3 parts which treat: (1) fundamental concepts; (2) room acoustics; and (3) the use of acoustical concepts in noise isolation and abatement.

The second part of the book is by far the most interesting. The author has done an excellent job of summarizing in a lucid and simple manner the important developments of the statistical theory of modern architectural acoustics. Numerous examples are given to illustrate the effect of diffusivity, reverberation time, and geometry on the acoustics of rooms.

The last chapter treats several structural and constructional procedures used in noise isolation and abatement treatments. In the spirit of the book, this chapter gives simple but correct explanations for the concepts behind the suggested designs.

As a whole, the book is a compact survey of the essentials of architectural acoustics by an old hand in the field and is recommended to students of architecture who are seriously interested in this phase of the field of acoustics.
O. K. Mawardi, USA

3105. Urick, R. J., and Hoover, R. M., Backscattering of sound from the sea surface: its measurement, causes, and application to the prediction of reverberation levels, *J. acoust. Soc. Amer.* **28,** 6, 1038–1042, Nov. 1956.

In many applications of underwater sound, the "reverberation," or backscattered return, from the sea surface is the limiting background in which the desired echo appears. Little has been known about sea-surface backscattering in spite of its importance to the prediction of reverberation levels in practical applications.

Using two transducers—one for transmitting, one for receiving—mounted so as to be rotatable in a vertical plane and suspended from a buoy, measurements have been made of the backscattering of sound pulses from the surface of the sea as a function of grazing angle between 5 and 90 degrees, wind speed between 3 and 18 knots, and pulse length. When converted to a scattering coefficient per unit area, the results provide some hints as to the processes by which sound is scattered by the ocean surface, and give the basic data for computing the reverberation to be expected with transducers of arbitrary beam width and orientation.
From authors' summary

3106. Eshelby, J. D., Supersonic dislocations and dislocations in dispersive media, *Proc. phys. Soc. Lond.* (*B*) **69,** 442, 1013–1019, Oct. 1956.

The conditions governing the motion of a screw dislocation at velocities above and below the velocity of shear waves are contrasted. For supersonic motion, the Peierls-Nabarro equation becomes a differential equation, in contrast to the subsonic integral equation. It has a solution representing a moving restoration of fit along a slip plane across which there was originally complete misfit.

In a dispersive medium where the sound velocity decreases with decreasing wave length, a discloation moving between the maximum

and minimum sound velocities suffers a retarding force, which may be calculated if the shape of the dislocation is supposed to be known. From author's summary

3107. Matsukawa, E., and Hunter, A. N., The variation of sound velocity with stress in sand, *Proc. phys. Soc. Lond.* (*B*) **69,** 440, 847–848 (Letters to the Editor), Aug. 1956.

3108. Schaaffs, W., Discontinuity of sound velocity at the melting point of some metals (in German), *Acustica* **6,** 4, 387–390, 1956.

3109. Sheehy, M. J., and Halley, R., Measurement of the attenuation of low-frequency underwater sound, *J. acoust. Soc. Amer.* **29,** 4, 464–469, Apr. 1957.

3110. Northwood, T. D., Smith, L. B., and Stevens, E. J., The acoustical design of enclosures for power transformers, *Noise Control* **3,** 2, 37–39, Mar. 1957.

Ballistics, Detonics (Explosions)

(See also Revs. 2982, 3064)

Book—3111. Assonov, V. A., Blasting works [Vzrivnie raboti], revised and enlarged 2nd ed., Moscow, Kharkov, Ugletekhizdat, 1953, 420 pp.; *Ref. Zh. Mekh.* 1956. Rev. no. 1446.

Book is intended as a textbook for mining colleges.

Chapter I gives a short historical survey of the development of blasting technique; chap. II contains brief information on the theory of blasting explosives; chap. III surveys industrial blasting explosives; chap. IV discusses blasting equipment; chap. V is concerned with the testing and destruction of defective blasting explosives; chap. VI deals with the transportation of blasting explosives; the subject of chap. VI is the storage, preparation and accounting for blasting equipment; chap. VIII contains a survey of the theory of action of explosives in a homogeneous medium; chap. IX investigates industrial blasting techniques; chap. X describes the methods of exploding blasting charges; chap. XI deals with the technique of execution of blasting works. In addition, a terminology of this branch of explosive engineering is given, the forms and records used are reviewed, and a bibliography included.

The book gives a fairly detailed summary of practical blasting methods used in the Soviet Union. The physical principles of the theory of the action of explosives on soils and rocks, and the corresponding mathematical foundations, are dealt with very summarily. G. I. Pokrovskii, USSR

Courtesy of Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

Book—3112. Brändli, H., Arms and their effect in anti-aircraft defense [Waffe und Wirkung bei der Fliegerabwehr], Basel, Birkhäuser Verlag, 1956, 91 pp. DM 26.

This monograph is a recent study on the probability of hitting an aircraft by ground fire. Starting with the customary relations for the probability of hitting a finite target by a gun having a known dispersion (or accuracy), author applies them to the general case projectile and target trajectories.

Particular attention is given to the effects of aircraft speed on the apparent rate of fire, and to evaluation of a weapon's effectiveness integrated over a selected length of trajectory (combat range). A formula is developed for the probability of hitting as a function of the time of flight in terms of hyperbolic tangents that offers much in simplicity over the comparable series expansion forms.

Closing sections are devoted to discussing the importance of such subjects as the time of flight, the use of accurate measurements, the apparent rate of fire (i.e., corrected for target-approach speed), and the variations introduced into the dispersion pattern by multiple mounts. Book is valuable contribution to the ground-to-air literature. C. E. Balleisen, USA

3113. Kapur, J. N., Uniqueness of maximum pressure for composite charges for orthodox, high-low pressure and leaking guns, by the equivalent charge method, Proc. First Congress on Theoretical and Applied mechanics, Nov. 1–2, 1955, pp. 227–238. Kharagpur, Indian Inst. of Technology.

Paper shows that only one peak can occur in the pressure-time curve when composite charges are used in (a) orthodox guns, (b) high-low pressure guns, (c) leaking guns (including recoilless). Uses quadratic form-function, covolume equal to solid propellant density, rate of burning proportional to pressure. In cases (b) and (c), the isothermal approximation is also used.

J. Corner, England

3114. Struble, R. A., and Black, H. D., A generalized closed form for burnt velocity, *Jet Propulsion* **27,** 2 (part 1), 151–155, Feb. 1957.

The equation of motion of a rocket neglecting gravitational field forces is integrated in closed form to yield a useful, easily applied design equation. In performing the integration, no assumptions are made concerning the dependence of the drag and thrust terms. Calculations and design graphs are given for those drag functions of most practical interest. Included is the case wherein the drag coefficient is constant at subsonic velocities, has a finite jump at Mach 1, and decays with increasing Mach number.

Reviewer believes that the results given in the paper are useful but that the omission of the gravity term may have significant effect in some cases, and hence that anyone using the results should do so with discretion. D. F. Gunder, USA

3115. Provart, R., The recovery of high speed rocket powered vehicles and/or their components, *Jet Propulsion* **27,** 2, 125–131, Feb. 1957.

Basic considerations of the recovery problem are presented, and details peculiar to the types of components to be recovered are noted. A discussion of the velocity, time, altitude, attitude (spinning, tumbling, etc.), and other trajectory conditions during which recovery may be initiated and/or effected is included. Various techniques of programming a recovery system are outlined and the methods of sensing environmental conditions which are pertinent to the recovery sequence are indicated. Several braking devices, their operation, advantages, and disadvantages are described. Recovery systems are compared through the use of efficiency, limitation, complexity, and reliability parameters. The presentation is summarized with a commentary on the range of application of parachute technology as it stands today. Devices and/or materials which appear to be promising for future use, and the problems associated with each of these, are indicated.

From author's summary

3116. Oswald, T. W., A note on missile launching, *J. aero. Sci.* **24,** 1, 74–76 (Readers' Forum), Jan. 1957.

3117. Thatcher, A. G., and Barton, H. A., Demonstration of reliability in liquid propellant rocket engines, *Jet Propulsion* **26,** 9, 781–785, Sept. 1956.

3118. Allen, S., Rocket engines, *J. roy. aero. Soc.* **61,** 555, 181–207, Mar. 1957.

3119. Zarovsky, J., and Gardiner, R. A., Flight investigation of a roll-stabilized missile configuration at varying angles of attack at Mach numbers between 0.8 and 1.79, *NACA TN* 3915, 36 pp., Jan. 1957.

Results are presented of a flight investigation of a rocket-propelled roll-stabilized model incorporating a gyro-actuated control and wing-tip ailerons. The model was disturbed in pitch and roll to determine the effect of these disturbances on the roll-stabilizing system.

The flight records indicate that satisfactory roll stabilization may be obtained from the combination of wing-tip ailerons and the gyroactuated automatic-control system during changes in angle of attack and roll trim at supersonic and roll trim at supersonic and transonic speeds. In addition to information on the autopilot performance, longitudinal performance data were determined from the flight records. From authors' summary

Soil Mechanics, Seepage

(See also Revs. 2886, 2887, 2948, 3131)

Book—3120. Caquot, A., and Kerisel, J., Mechanics of soils [Traite de mecanique des sols], 3rd ed., Paris, Gauthier-Villars, 1956, xiv + 558 pp.

Although authors recognize the manifold limitations imposed by nature on the application of mathematics to problems in earthwork engineering, they think that experiments need only furnish correct bases for the mathematical developments whose results, however, must be verified by experiments. The treatise of the authors is, therefore, in the general style of the French creators of soil mechanics (namely, of Boussinesq and Resal). However, the mathematical developments of the new edition are simplified and shortened in order to increase the extent and profundity of the part dealing with the physical properties of soils.

After a separate study of each of the three phases, solid, liquid, and gaseous, authors present the properties of the complex solid-liquid-gas. The presentation of capillarity is especially developed, characterizing soil-moisture phenomena by energy relationships, from which authors deduce the behavior of clays. The study of the mechanical properties of the complex are presented in a series of chapters in the second part: relationship between stresses and small deformations; computation of settlements and their evolution with time; acoustic and vibrating phenomena, etc. Authors recall the conditions for the equilibrium of matter and conclude this second part with the study of the shearing resistance in soils both with and without cohesion. They present statistical relationships between the angle of internal friction of soils and their void ratio on the one side, and between the cohesion of clays and their water content on the other side.

Part III deals with the application of the present knowledge of soil behavior and of the theories of soil mechanics to design and construction in the field of foundation and earthwork engineering. Authors enhance their former editions by presenting separately the tables for both active and passive earth pressure. It is not possible to describe this third part in detail but the following points deserve special attention: experiments for the verification of theoretical results for passive earth pressure, development of formulas for deep foundations, deduction of a formula for computing settlement under circular foundations, etc.

L. J. Tison, Belgium

Book—3121. Seelye, E. E., Foundations. Design and practice, New York, John Wiley and Sons, Inc., 1956, xvi + 425 pp. $16.

Book is written for practicing design engineer, builder, inspector, architect, teacher, and student, and to assist engineers and architects in subsurface exploration, foundation reports, specifications, estimates, contracts, and in design of good foundations for buildings, bridges, dams, sewers, etc. It is organized for: (1) "Push-button" design of simple elements (plate footings, retaining walls, etc.); (2) more complex designs of various allied problems (e.g., combined footings, settlement); (3) economy from consideration of various alternate designs; (4) wide variety of other foundation types; (5) field methods and practice (underpinning, shoring); (6) basic principles of soil mechanics.

Book is amply illustrated and includes valuable tables and examples of applications. J. J. Polivka, USA

Book—3122. Bazant, Z., Methods of foundation engineering [Methody Zakladani Staveb], Praha, Nakladatelstvi Ceskoslovenske Akademie VED, 1956, 548 pp.

This very good and complete book is used in author's classes at Prague Technical University and by professional engineers. It is based on author's 25-year practical experience and study of foundation problems in many European countries and also in USA, Australia, New Zealand, and with many references to research and publications of his predecessor, Prof. B. Tolman. Book concentrates on foundation methods commonly used today, and their progress. Theory and practical applications are subjects of another volume in preparation. Special emphasis is given to mechanization and economy, often overlooked in similar publications.

Book is valuable not only for designers but also for builders and supervising engineers. Author invites the readers to submit suggestions for revisions and additions to be considered in the next edition. Reviewer believes that more thorough description should be given intrusion and prepacked methods, mentioned briefly on p. 495, which were originated by Raymond E. Davis about 20 years ago and used in wide variety of foundation stabilization, solidification, and underpinning problems. Also prepacked concrete is being successfully used all over the world. Also chemical soil solidification should be presented more thoroughly, especially methods invented by Hugo Joosten, Lars Jorgensen, Soil Solidification Engineers, Inc., etc. J. J. Polivka, USA

3123. Gates, M., Empirical formula for predicting pile bearing capacity, *Civ. Engng., N. Y.* **27,** 3, 65–66, Mar. 1957.

3124. Holmberg, A., Influence of foundation depth on cohesionless soils, *Geotechnique, Lond.* **6,** 3, 115–117, Sept. 1956.

3125. Stables, E. R., The skid-wheel: new method of moving heavy loads on soft ground, *Engineering* **183,** 4754, 494–497, Apr. 1957.

3126. Stutzman, L. F., and Thodos, G., Frontal drive production mechanisms—a new method for calculating the displacing fluid saturation at breakthrough, *J. Petr. Technol.* **9,** 4, 67–69, Apr. 1957.

A variation in the Leverett-Buckley method is described and illustrated by an example of frontal flood advance in a water injection case. For cases involving displacement of gas, authors claim their method is more conveniently used than that of Leverett-Buckley. S. R. Faris, USA

3127. Czerniak, E., Resistance to overturning of single, short piles, *Proc. Amer. Soc. civ. Engrs.* **83,** (*J. Struct. Div.*), ST 2, Pap. 1188, 26 pp., Mar. 1957.

Safe overturning resistance of short piles is estimated by means of simplifying assumptions. Pile is considered rigid. Ultimate lateral resistance of soil for safety factor purposes is calculated from Rankine's equation for passive resistance. Charts permit the selection of the economical diameter and depth of embedment for various loadings and restraints. Modulus of elasticity of soil is based on code values. Author cautions users that soil tests and exploration must be carried out. Precision implied by the author seems too optimistic. K. N. Hendrickson, USA

3128. Marshall, T. J., A plummet balance for measuring the size distribution of soil particles, *Austral. J. appl. Sci.* **7,** 2, 142–147, June 1956.

A simple balance is described for use with a plummet in measuring the density of soil suspensions. The only manipulation required is to adjust for depth of immersion of the plummet. The percentage of soil in suspension at a given depth and time is read on a scale by means of a pointer.

Suitable calibration procedures are given, and some factors affecting the measurements are discussed.

From author's summary

3129. Beliakova, V. K., Unsteady inflow of underground water to wells (in Russian), *Prikl. Mat. Mekh.* **20**, 1, 109–115, Jan./Feb. 1956.

Author's solution of title problem is based on known methods applied to flow in wells and sewers, especially those developed by Polubarinova-Kochina and N. Boulton. Method of approximation is used and verified for several simplified cases. Following special cases are investigated theoretically: (1) Sewers built in strata of unlimited thickness. (2) Inflow of underground water to drain wells installed over water table. (3) Inflow in nonhomogeneous ground. (4) Wells in homogeneous ground. (5) Wells in homogeneous strata of limited thickness. J. J. Polivka, USA

Micromeritics

(See also Revs. 2948, 3126, 2129)

Book—3130. Cadle, R. D., Particle size determination, Man. 7, New York, Interscience Publishers, Inc., 1955, xv + 303 pp. + 45 fig. + 239 ref. $5.50.

A detailed, systematic and critical treatment is given of the title subject. While it mainly considers solid particles, yet several chapters, and parts of other chapters, apply equally to liquid particles. The range of subjects are best indicated by the chapter headings which are as follows:

I. Introduction (particle size range; effect of size on properties of particles; specific applications; meaning of terms). II. Treatment of data (general concepts; size averages; distribution functions; graphical representation of data). III. Sampling methods (choice of technique; sampling; selection of method). IV. Optical microscopy (the microscope; illumination; slide preparation; measuring the particles; types of diameters; comparison with other methods). V. Electron microscopy (types of electron microscopes; operation; specimen preparation; size measurement; comparison with other methods). VI. Sieve analysis (types of sieves; calibration of screens; treatment of results; comparison with other methods). VII. Sedimentation and elutriation (general principles; preparation of suspensions; cumulative methods; change of concentration at a given level; decantation; centrifugal methods; elutriation). VIII. Surface area measurement (permeability; adsorption of solutes from solution; adsorption of gases; heat of immersion).

IX. Optical methods (the "owl", a chamber in which an aerosol is illuminated and observed with a low-power microscope; coronae, based on diffraction rings observed at a distant light source when viewed through a layer of particles of uniform size; methods based on properties of transmitted light; methods based on intensity of scattered light; x-ray measurements; tinting strength). X. Miscellaneous methods (electrostatic particle counter; diffusion; sonic methods; bulk density).

A special commendable feature of the book is that, for each method, a succinct theory is given, and that description of experimental methods includes tricks and detailed explanations for obtaining consistent results.

K. J. DeJuhasz, Germany

3131. Klinkenberg, L. J., Pore size distribution of porous media and displacement experiments with miscible liquids, *J. Petr. Technol.* **9**, 4, 63–66, Apr. 1957.

For consolidated porous media pore-size distributions are obtained from results of miscible liquid displacement experiments. A porous medium is assumed to consist of a set of straight, cylindrical, parallel, noninterconnected capillaries. It is necessary that displacement procede under conditions such that diffusion between the displaced and displacing liquids can serve to flatten the boundary between liquids. Pore-size distributions thus obtained disagree with pore-size distributions obtained by mercury injection techniques. Author concludes pore-size distributions are dependent upon methods used to obtain them, and that the current concept of pore-size distribution is not unequivocally defined. S. R. Faris, USA

3132. Wieland, V. W., Considerations on the determination of the specific surface of powders by the Blaine equipment, *Zement-Kalk-Gips* **10**, 3, 81–88, 1957.

3133. Ter Linden, A. J., Experimental investigations of air filters (in Dutch), *Ingenieur* **68**, 50, 63–70, Dec. 1956.

Several types of air filters in use for airconditioning installations (fabric, electrostatic, and viscous filters) have been tested in the "Laboratorium voor Warmte- en Stoftechniek" of the Delft Technical University.

The resistance, the collecting efficiency, and the dust-holding capacity of the filters have been measured by varying air velocities, and for different kinds of dust.

The influence of the quantity of dust assembled in the air filters on the resistance and the collecting efficiency have been determined.

Contrary to expectation, some of the filters showed a much lower collecting efficiency for the coarse particles of fly-dust of a chain grate stoker than for much finer coal and clay dust particles.

From author's summary

3134. Roberts, S. M., The application of an electronic computer to the calculation of the recovery of natural gasoline by refrigeration, *J. Petr. Technol.* **8**, 12, 24–29, Dec. 1956.

3135. Corey, A. T., Rathjens, C. H., Henderson, J. H., and Wyllie, M. R. J., Three-phase relative permeability, *J. Petr. Technol.* **8**, 11, 63–65, Nov. 1956.

The results of three-phase relative permeability tests on nine water-wet consolidated Berea sandstone samples are presented as composite ternary diagrams showing isoperms of oil, water, and gas. Capillary pressure control was exercised over the flow of gas and oil in the presence of water. The water saturations ranged from 17 to 71% pore volume.

A method of calculating both the oil and water permeabilities of a three-phase system from the easily measured gas relative permeability is presented. From authors' summary

3136. Shvidler, N. I., Interference of wells in the case of "elastic regime" in oil pumping (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 5, 42–49, May 1955.

Problem is to evaluate well discharge in pumping oil out of porous compressible media. Author considers two-dimensional nonsteady flow problem. Enclosing the wells, a "fictitious feeding contour" C is introduced at proper distance from wells. In (A) (within C), fluid is regarded as incompressible, and a classical expression for discharge $\overline{Q}$ of wells is postulated in terms of pressure at well, $P_w(t)$, and of that on C, $P_c(t)$. $P_c(t)$ is unknown. In (B) (without C), pressure P satisfies the heat equation ("elastic regime") $P_t = \alpha^2 P_{xx}$, [I]. Initially $P = P_0$ everywhere; at $t = 0$, pumping begins.

Laplace transform $P^*(s)$ of $P(t)$ and of equation [I] yield, with boundary conditions, expression for $P^*(s)$. Through transform of the continuity condition on C, transform $Q^*(s)$ of the discharge $Q(t)$ is found. Comparison of $Q^*(s)$ and of transform of $\overline{Q}$ gives expression for P^*_c, hence $P_c(t)$ and the discharge.

In case (1), C is the boundary of an infinite strip; wells lie on axis and are equidistant (chain of wells). Computations lead to

Erf functions. In case (2), C is a circle; wells are arranged equidistantly on a smaller concentric circle (circular battery). Computations lead to integrals involving Bessel functions. A numerical procedure is required for their evaluation. For each case, author gives expressions for pressure P_c on C, and wells discharge. An example of each case is worked out. Results show that, for comparable conditions, initial discharge is slightly larger in (1) than in (2). Later on, discharge is much larger in (2) than in (1). G. H. Beguin, Switzerland

3137. Belousov, V. D., Problem of the free output of gas apertures (in Russian), *Trans. Moscou Petroleum Inst.* no. 14, 250–263, 1955; *Ref. Zh. Mekh.* 1956, Rev. no. 2997.

A method is proposed for determining the free output of gas apertures, similar to the method of selecting centrifugal pumps.

The output/pressure graph on the face for the exploitation column is plotted according to the theoretical formula obtained from examination of the gas flow through the vertical pipe on the following assumptions: the flow is unidimensional, there is an absence of heat exchange with the surrounding medium, the coefficient of hydraulic resistance is constant.

Output/pressure graph on the face for the stratum is plotted from the given tests of the aperture. Treatment of these data is performed according to the law

$$p_1^2 = a_q^2 + b_q + o$$

in which p_1 is the pressure on the face, q the output, a, b, c are the constant coefficients [see I. A. Charhyi, *Izv. Akad Nauk SSSR Otd. tekh. Nauk.*, no. 6, 1956].

The free output is determined by the point of intersection of both graphs. An analysis is made of the subcritical and critical cases of gas discharge from the column, the possibility being shown of using a more simple formula of the critical discharge in subcritical conditions. V. L. Davilov, USSR

Courtesy Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

3138. Kazarinov, F. G., The aerodynamic bases of a rotating suspended layer (in Russian), *Trudi. Vses. n-i. in-ta po pererabotke slantsev* no. 3, 145–159, 1955; *Ref. Zh. Mekh.* 1956, Rev. no. 2883.

An explanation is given of certain elementary concepts relating to the aerodynamics of thermal treatment of small grain fuel in a rotating suspended layer used in the VNIIPS gas generator.

From the condition of equilibrium of forces acting on a separate particle of fuel in a vertically rising and in a rotating gas flow, it is determined that the relative velocity of motion of the gas and the intensity of draught in the case of a circular flow may be greater than in the case of the rising motion of gas.

Courtesy Referativnyi Zhurnal D. M. Mints, USSR
Translation, courtesy Ministry of Supply, England

3139. Hesse, H., Transportation of sediments in pipe lines (in German), *Ing.-Arch.* **24**, 5, 299–307, 1956.

Paper is a theoretical study of sediment transportation in pipes by means of an air stream. Author establishes the theory of unsteady motion, applying the momentum equation successively to the general motion, to the air motion, and to the sediment motion. Resistance between air and sediment is expressed in terms of the power $2\text{-}n$ (with $n < 1$) of the ratio $(v\text{-}c)/w$, where $v\text{-}c$ is the relative velocity of air with regard to sediment and w is the fall velocity of the grains of sediment in air. c changes with the concentration of the sediment in air and n depends on $(v\text{-}c)$. Author integrates the obtained equations for different values of n and finds expressions of c and of the pressure for a variation of the distance of travel.

From this general study of unsteady motion, author deduces the laws of steady motion. L. J. Tison, Belgium

Geophysics, Meteorology, Oceanography

(See also Revs. 3066, 3102)

3140. Ogura, Y., Wave solutions of the vorticity equation for the 2½-dimensional model, *J. Meteor.* **14**, 1, 60–64, Feb. 1957.

Wave solutions of the nonlinear quasi-geostrophic equations for the "2½-dimensional method" without friction are derived for the case of the disturbances φ superimposed on the zonal basic current and are given in the forms of $\varphi(t) \exp i(kx + my)$, where t is the time, x and y are Cartesian coordinates pointing eastward and northward, respectively. Then the nonlinear terms of the quasi-geostrophic equations for the 2-layer model given by Charney and Phillips [AMR **6**, Rev. 3938] drop out. The solutions obtained describe wave motions which propagate at different speeds in each layer. The disturbances are either stable or unstable; the critical value of wave length is expressed as a function of thermal stability and of vertical wind shear in the basic current. The inclination of trough lines to the vertical increases monotonically with time in stable waves, and it varies slowly in the unstable wave, tending to a certain limiting value. H. Arakawa, Japan

3141. Long, R. R., Sources and sinks at the axis of a rotating liquid, *Quart. J. Mech. appl. Math.* **9**, 4, 385–393, Dec. 1956.

An experimental and theoretical study is made of a rotating semi-infinite circular-cylindrical column of fluid with a point source or sink at the end of the axis. The fluid at infinity is assumed to have uniform axial velocity and angular velocity. An analytical solution is found on the basis of inviscid incompressible flow characterized by a dimensionless number Ro, called the Rossby number, the ratio of the inertial force due to axial velocity to the Corilois force due to rotation. The solution is given for values of $Ro > 0.261$ with free stationary waves invalidating the solution for lesser values. At large values of Ro, the sink draws fluid from the entire cylindrical cross section; but near the critical value, reverse flow develops in the part of the fluid near the cylinder wall, and the sink draws fluid from the inner regions in the form of a jet. Experimental flow patterns photographed with aluminum particles as tracers confirm these qualitative predictions of the theory. For values of $Ro < 0.261$, the photographs show decreasing size until, at a value of 0.006, the jet is concentrated near the axis and spins about 60 times as rapidly as the main mass of fluid.

J. Nielson, USA

3142. East, T. W. R., The intensity of turbulence in convective clouds, *Quart J. roy. meteor. Soc.* **83**, 355, 121–126, Jan. 1957.

Calculations of collision rates between cloud droplets in turbulent air show that this would be an effective precipitation mechanism in cumulus if the r.m.s. turbulent acceleration were about three times that due to gravity. An estimated value, based on published records of flights through thunderstorms, is about one-sixth of gravity. In the absence of more direct evidence, it seems that turbulence is not an important factor in convective precipitation. From author's summary

3143. Clodman, J., Anisotropic high-level turbulence, *Quart. J. roy. meteor. Soc.* **83**, 355, 116–120, Jan. 1957.

A study is made of several cases of high-level turbulence in which the intensity varied with the direction of flight of the aircraft. The direction of maximum turbulence is found to coincide fairly well with the direction of the contour lines. A theory is developed which attributes this type of turbulence to quasi-horizontal gusts associated with strong horizontal wind shear. Gravity waves are examined as possible alternative explanation and tentatively rejected. From author's summary

Lubrication; Bearings; Wear

(See also Rev. 2913)

3144. Aoki, S., and Furukawa, I., On the clearance of ball bearing in running state, *J. mech. Lab. Tokyo* **2,** 2, 29–33, 1956.

Tests on 30-mm-bore ball bearings at speeds up to 3600 rpm and axial loads up to 350 Kg are reported. The relative axial movement of the two races was measured and shown to vary with conditions of operation. It is inferred from inner and outer race temperatures that the thermal expansion of the balls is an important factor and that axial movements measured may be accounted for quantitatively by assuming that their temperature is nearly equal to the temperature of the inner surface of the inner race.

F. T. Barwell, Scotland

3145. Sternlicht, B., and Maginniss, F. J., Application of digital computers to bearing design, ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56-A-73, 34 pp.

3146. Christopherson, D. G., Boundary conditions in lubricating films, *Engineer 203,* 5269, p. 100, Jan. 1957.

3147. Kreisle, L. F., Surface roughness—A criterion for minimum hydrodynamic oil-film thickness of short journal bearings, ASME-ASLE Lub.Conf., Atlantic City, N. J., Oct. 1956. Pap 56-LUB-5, 9 pp.

The minimum hydrodynamic oil-film thickness of a short journal bearing is defined as that value of the minimum oil-film thickness at which marginal procedures initially are substituted for hydrodynamic-film lubrication. This appears to occur when the minimum oil-film thickness equals the sum of the predominant-peak surface roughnesses of the bearing and journal, measured in the circumferential direction after run-in of bearing and journal.

From author's summary

3148. Hersey, M. D., and Snapp, R. B., Testing dynamically loaded bearings—I, A short history of bearing test machines, ASME-ASLE Lub. Conf., Atlantic City, N. J., Oct. 1956. Pap. 56-LUB-3, 18 pp.

Bearing test machines with dynamic loading or nonuniform motion are described in this paper and classified according to the type of loading employed. Over thirty such machines have been disclosed in the published literature, including both endurance machines and research machines for investigating oil-film performance. The authors have endeavored to find answers to six questions concerning each machine—(*a*) its loading mechanism, (*b*) test bearing details, (*c*) range of variables, (*d*) performance criteria, (*e*) characteristic limitations or advantages, and (*f*) extent of use.

From authors' summary

Marine Engineering Problems

3149. Schuster, S., Hydrodynamically caused thrust and torque oscillations in ship propulsion equipment (in German), *ZVDI* **98,** 32, 1789–1794, Nov. 1956.

The periodic load of a screw in the wake of a ship is approximately analyzed by simplified considerations and representation by powers of trigonometrical functions. The merits of screws with certain numbers of blades are discussed in connection with deviations from mean values of thrust and torque.

E. Hogner, Sweden

3150. Palermo, P. N., and Brock, J. S., Investigation of pressures on keel blocks during drydocking of USS Valley Forge (CVS 45), and USS Intrepid (CVA 11), *David W. Taylor Mod. Basin Rep.* 1003, 33 pp., Apr. 1956.

Loads on the keel blocks during drydocking of three aircraft carriers were determined by means of pressure wafers placed under the docking piers. The purpose was to study the loads on the keel blocks, especially in the area of the stern overhang, as these loads are sometimes the controlling factor in the design of the stern. For the three ships tested the maximum load was at least twice as great as the nominal load and did not occur at the aftermost block as expected but at a distance of 40 to 70 ft forward of this block.

Several theories of computing keel-block loads are discussed. A new TMB approximate method is presented which assumes the ship to be a simple beam on an elastic foundation. This method proved to be rapid and adequate to determine the loads on the after blocks.

From authors' summary

3151. Wilson, W. K., A review of ship vibration problems, *J. Amer. Soc. nav. Engrs.* **68,** 2, 312–326, May 1956.

3152. Greenspon, J. E., Jasper, N. H., and Birmingham, J. T., Sea tests of the USCGC "UNIMAK"; pressures, strains and deflections of the bottom plating incident to slamming, *Inter. Shipbldg. Progr.* **3,** 25, 474–486, Sept. 1956.

Report presents and discusses some of the test data taken in the early part of 1955 during rough-water sea trials of a Coast Guard cutter on weather patrol duty. The data include the impact pressures incident to slamming as well as the corresponding strains and deflections of the forward bottom plating. These measurements are compared with results obtained from theoretical considerations, and strength estimates are made for typical bottom plates of selected ships.

From authors' summary

3153. British Hydrodynamic Lab gives underwater data, *Indust. Lab.* **8,** 2, 25–27, Feb. 1957.

3154. van Lammeren, W. P. A., and Vossers, G., The Seakeeping Laboratory of the Netherlands ship model basin, *Inter. Shipbldg. Progr.* **4,** 29, 3–23, Jan. 1957.

Books Received for Review

ASTBURY, N. F., Introduction to electrical applied physics, New York, Philosophical Library, Inc., 1957, xi + 241 pp. $10.00.

BELEVITCH, V., Langage des machines et langage humain, No. 120, Bruxelles, Office de Publicité, 1956, 121 pp. 80 francs.

BONILLA, C. F., edited by, Nuclear engineering, New York, McGraw-Hill Book Company, Inc., 1957, x + 843 pp. $12.50.

BRUNST, B., Die induktive Wärmebehandlung, Berlin, Springer-Verlag, 1957, xii + 240 pp. DM 43.50.

CASAMASSA, J. V., edited by, Jet aircraft power systems, principles and maintenance, New York, McGraw-Hill Book Company, Inc., 1950, x + 338 pp.

CHARON, P., La methode de Cross et le calcul pratique des constructions hyperstatiques, theorie et applications, Paris, Editions Eyrolles, 1955, xi + 302 pp.

COMINGS, E. W., High pressure technology, New York, McGraw-Hill Book Company, Inc., 1956, xi + 572 pp. $11.50.

COUFFIGNAL, L., Resolution numerique des systemes d'equations lineaires, Vol. II, Paris, Gauthier-Villars, 1956, iii + 180 pp. $5.86.

ECKERT, W. J., and JONES, REBECCA, Faster, faster; a simple description of a giant electronic calculator and the problems it solves, New York, McGraw-Hill Book Company, Inc., 1955, vii + 160 pp. $3.75.

FEDERER, W. T., Experimental design, theory and application, New York, The Macmillan Company, 1955, xix + 591 pp. $11.00.

FERMI, E., Thermodynamics, New York, Dover Publications, 1956, second edition, x + 160 pp. $1.75, (paperbound).

FERRY, A., Expose critique des principaux systemes; systeme Giorgi, Paris, Gauthier-Villars, Editeur-Imprimeur-Libraire, 1956, x + 54 pp. + 4 figs. $2.94.

GEYER, H., and OPPELT, W., edited by, Volkswirtschaftliche Regelungsvorgänge im Vergleich zu Regelungsvorgängen der Technik, München, R. Oldenbourg, 1957, 143 pp. DM 13.50.

GOLDMAN, J. E., edited by, The science of engineering materials, New York, John Wiley & Sons, Inc., 1957, xv + 528 pp. $12.00.

GOLEEVSKII, A. A., Boprosy mekhaniki struinogo dvizheniya zhidkostei i gazov, Moscow, Gosudarstvennoe Nauchno-Tekhnicheskoe Izdatel'stvo Mashinostroitel'noi Literaturya, 1957, 88 pp.

HALL, H. D., and LINSLEY, H. E., Machine tools—what they are, and how they work, New York, The Industrial Press, 1957, xi + 436 pp. $5.50.

HENRY, F. D. C., The design and construction of engineering foundations, New York, McGraw-Hill Book Company, Inc., 1956, xviii + 547 pp.

HOHENEMSER, Fluglehre, Berlin, Springer-Verlag, 1957, xi + 402 pp. FM 25.50.

HOUWINK, R., Plasticity, elasticity and structure of matter, Washington, D. C., Harren Press, 1953, xviii + 368 pp. $2.98.

Jahrbuch der Wissenschaftlichen Gesellschaft für Luftfahrt E. V. (WGL), Braunschweig, Friedr. Vieweg & Sohn, 1956, xix + 247 pp. DM 38.

JOHNSON, R. E., and KEOKEMEISTER, F. L., Calculus with analytic geometry, Boston, Mass., Allyn and Bacon, Inc., 1957, xi + 650 pp. $7.50.

JONES, G. A., Modern applied photography, New York, Philosophical Library, Inc., 1957, vi + 162 pp. $4.75.

KORN, G. A., and KORN, THERESA M., Electronic analog computers (D-c analog computers), 2nd ed., New York, McGraw-Hill Book Company, Inc., 1956, xiv + 452 pp. $7.50.

LAUGHNER, V. H., and HARGAN, A. D., Handbook of fastening and joining of metal parts, New York, McGraw-Hill Book Company, Inc., viii + 622 pp. $15.00.

LINDSAY, R. B., and MARGENAU, H., Foundations of physics, 2nd ed., New York, Dover Publications, 1957, xi + 542 pp. $2.45.

LONG, R. R., Fluid models in geophysics, Proceedings of the first symposium on the use of models in geophysical fluid dynamics, Johns Hopkins University, Sept. 1953. Washington, D. C., 1956, U. S. Government Printing Office, v + 162 pp. $2.25.

MISES, R., and VON KARMAN, T., edited by, Problemy mekhaniki, Sbornik Statei, Moscow, Izdatel'stvo Inostrannoi Literatury, 1955, 538 pp. (Translated from *Advances in Applied Mechanics.*)

PARKER, E. R., Brittle behavior of engineering structures, New York, John Wiley & Sons, Inc., 1957, xv + 323 pp.

PEARSON, S. W., THRING, M. W., and CHESTERS, J. H., Combustion and heat transfer in an open-hearth furnace, Special Rep. no. 59, London, The Iron and Steel Institute, 1956, viii + 82 pp. 37s. 6d.

PFLUGER, A., Elementare Schalenstatik—Zweite erweiterte Auflage, Berlin, Springer-Verlag, 1957, vii + 112 pp. DM 19.50.

POLANYI, M., compiled by, Dictionary of textile terms [Textil Fachworterbuch] German-English, English-German, New York, Pergamon Press, 1956, x + 328 pp. $10.00.

SHANNON, C. E., and McCARTHY, J., edited by, Automata studies, Princeton, New Jersey, Princeton University Press, 1956, x + 286 pp. $4.00.

SISCO, F. T., edited by, Boron, calcium, columbium and zirconium in iron and steel, New York, John Wiley & Sons, Inc., 1957, xi + 533 pp. $14.00.

Underground corrosion, Washington, D. C., U. S. Department of Commerce, National Bureau of Standards Circular 579, April 1957, iv + 227 pp. $3.00.

WILCOCK, D. F., and BOOSER, E. R., Bearing design and application, New York, McGraw-Hill Book Company, Inc., 1957, xii + 464 pp. $12.50.

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